Fire, Smoke, and Haze

The ASEAN Response Strategy




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Association of Southeast Asian Nations

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Contents

Appendixes

List of Boxes

List of Figures

List of Tables

List of Photographs

Message

1997 and 1998 were crisis years for the Association of Southeast Asian Nations (ASEAN). The financial turmoil that hit ASEAN countries' economies during this period was compounded by the haze that enveloped a good part of the region. The pernicious practice of burning forests to clear land for commercial purposes and the unusually dry weather that caused even the earth to catch fire combined to produce a pall of catastrophic proportions. The loss in terms of agricultural production, transportation, tourism, and other economic endeavors has been estimated at more than $9 billion. The cost to human health, loss of biodiversity, destruction of forests, and general environmental degradation is immeasurable.

ASEAN's response was swift. ASEAN Ministers met frequently to draw up measures to deal with the problem. They adopted a Regional Haze Action Plan (RHAP), with corresponding national action plans and implementation measures, prescribing urgent action on three fronts—monitoring, prevention, and mitigation. Resources were mobilized and action undertaken to carry out these plans.

The ASEAN Specialized Meteorological Centre in Singapore has been strengthened to more effectively detect hot spots, predict the weather, and provide early warning of fires. Firefighting mechanisms have been organized in fire-prone areas and operational exercises have been carried out. Meetings with plantation owners and forest concessionaires have been organized to impress upon them the seriousness of the zero-burning policy that ASEAN has adopted. And the ASEAN Secretariat has set up a special unit to coordinate efforts to deal with the haze problem. Meanwhile, in the long term, the ASEAN Environment Ministers have agreed to work on an ASEAN Agreement on Transboundary Haze Pollution.

In all this, ASEAN has received the support of the Asian Development Bank (ADB), Global Environment Facility (GEF), United Nations Environment Programme, United Nations Development Programme, individual governments, and nongovernment organizations (NGOs).

This publication, a joint effort of ADB and ASEAN, brings together the current knowledge about land and forest fires, examines their causes and impacts with particular reference to Southeast Asia, and suggests what could happen in the future. It describes and assesses ASEAN's response to the haze phenomenon and the role of ADB and other international bodies. Finally, it lays down a blueprint for future national, regional, and global action to deal with the haze problem in Southeast Asia.

This work should, therefore, be of great interest to many—national governments, regional and international organizations, NGOs, and the media, which wrote so much about the disaster when it occurred but little about the measures that have been taken to address it.

I wish to extend to ADB ASEAN's congratulations and appreciation for this publication, a most valuable contribution to the reasoned discourse on a serious international problem, with constructive proposals for action to deal with it. I would also like to reiterate ASEAN's thanks to ADB for its unremitting support for ASEAN's response to the haze crisis. In so doing, I reaffirm ASEAN's commitment and resolve to ensure that this disaster does not happen again on such a devastating scale.

RODOLFO C. SEVERINO Jr.
Secretary-General
Association of Southeast Asian Nations

Foreword

Every year, millions of hectares of the world's forests are consumed by a large number of fires, resulting in billions of dollars in suppression costs and causing tremendous damage, health problems, and even deaths. The forest fires that have hit the Association of Southeast Asian Nations (ASEAN) countries, especially Indonesia, have been particularly severe, with the United Nations Environment Programme labeling the blaze of 1997-1998 among the most damaging in recorded history. The environmental, economic, and social dimensions and impact of these catastrophic fires, and the associated transboundary atmospheric haze pollution, were profound.

Most tropical fires are set or spread accidentally or intentionally by humans. When severe droughts over the last two decades have combined with large-scale logging in the rain forests and indiscriminate use of fire for land clearance, the results have been devastating. As a result of these and other contributory factors, all areas of ASEAN are prone to wildfires, which are likely to remain a serious threat for some time.

As a partnership for sharing experiences, information, responsibilities, and benefits, and working toward common good through joint efforts and approach, ASEAN is in a strong position to address its fire problem at the regional level. Following the 1997 fires, the affected ASEAN countries assumed a more operational stance toward the fire and haze disasters. Major initiatives in response to the 1997-1998 fires included national strategies for coordinated action and collaborative regional efforts. At the ASEAN level, a Regional Haze Action Plan (RHAP) was formulated and endorsed by ASEAN Environment Ministers in Singapore on 23 December 1997. The adoption of this instrument has proved to be a turning point in the region's approach to preventing and mitigating the damage from recurrent fires and haze. The RHAP document is a reflection of ASEAN's determination to actively tackle the problem.

The Asian Development Bank (ADB) has been playing its part, supporting and catalyzing action to prevent and mitigate the impact of forest fires and haze. It has provided technical assistance at the regional level through the ASEAN Secretariat and advisory technical assistance at the national level to Indonesia.

Intended as a reference source and general guide for fire and haze management in the ASEAN region, this volume primarily targets policymakers and professionals at the regional level and in the ASEAN member countries, as well as in other donor countries and agencies. As such, it reviews the fire and haze situation in the region, but putting it into an overall global context. It draws on the findings of ADB's two related technical assistance projects, including lessons learned and proposals for follow-up in the short and medium term.

The volume is organized into two main parts.

THE PREMISE *presents in the first three chapters background information relating to forest fires and associated haze, comparing global responses and initiatives to address the situation. In particular, the situation in ASEAN is dealt with in some detail.*

Chapter 1 focuses on the increasing incidence and intensity of forest fires and haze in recent years, analyzing the major causes and developments in fire science and technology to address these problems. There is also a brief account of international action to address forest fires and haze.

Chapter 2 goes into some detail on the fires and haze that have affected the ASEAN region, providing analysis on the causes, and the constraints that have exacerbated these causes. Forestland conversion *involving uncontrolled use of fire in land preparation is identified as a major source of fires, the environmental, economic, and social aspects of which are examined.*

Chapter 3 discusses the responses at several levels to the recent forest fires and haze in the ASEAN region, particularly the occurrences of 1997-1998. It also provides an analysis of recent trends in donor assistance.

THE PROGRAM, *containing Chapters 4 to 6, discusses the programs being implemented in the ASEAN region, including regional, subregional, and national components of the Operationalized Regional Haze Action Plan (ORHAP), to enhance regional preparedness to meet any future occurrences of forest fires and haze.*

Chapter 4 details ADB's two-pronged approach to address transboundary atmospheric pollution in the region through its advisory technical assistance grant to Indonesia and regional technical assistance grant to ASEAN. It describes the catalytic role intended, objectives and details of activities, as well as the results achieved and lessons learned.

Chapter 5 explains the ORHAP and how it is closely linked to, and supportive of, actions at subregional, national, and local levels in ASEAN. The three main program components of prevention, mitigation, and monitoring and the institutional arrangements for implementation are discussed in detail with references to the activities and actions falling under each.

Chapter 6 looks at the important actions required to consolidate the initiatives undertaken so far and to promote and implement appropriate forest fire management in the region, to support rational land use and development. A lesson learned is that cooperation, openness, and dissemination of results among projects and relevant government departments is of paramount importance, as is a participatory approach. Millions of people living in rural areas depend on forests for their livelihood. Often, their aspirations for a more decent, secure, and equitable way of life are tied up with forestry development. Organized and informed participation of these people can help all parties involved to find solutions to their problems. The likelihood (in terms of number and intensity) of forest fires can be reduced through rational and balanced management interventions with the full participation of local communities.

A bibliography and six Appendixes follow, providing a glossary of local and technical terms, ongoing assistance programs and activities of the RHAP, procedures for formulating and implementing a Fire Suppression Mobilization Plan, fire danger rating systems, funding agencies' collaboration to combat forest fires and haze, and an outline of the ASEAN Haze Action Online.

ADB stands ready to provide the necessary assistance at the regional as well as at the national level in support of the efforts aimed at addressing the underlying causes of forest fires and associated haze as documented in this publication. But it is important to recognize that the initiative and responsibility for successful implementation rest with the countries concerned. Regional organizations such as ASEAN can act as a facilitator and coordinator of bilateral or multilateral support, using its influence and capacity to mobilize intraregional cooperation and collaboration in dealing with the challenge. In this context, as the publication points out, the emphasis has to be on prevention, because as the old axiom goes, "prevention is better than cure."

ROLF SELROD ZELIUS
Chief, Office of Environment and Social Development
Asian Development Bank

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Abbreviations and Acronyms

ADB	Asian Development Bank
ADPC	Asian Disaster Preparedness Center
ADTA	advisory technical assistance
AMC	ASEAN member country
AMMH	ASEAN Ministerial Meeting on Haze
API	Air Pollution Index
ASEAN	Association of Southeast Asian Nations
ASMC	ASEAN Specialized Meteorological Centre
ASOEN	ASEAN Senior Officials on Environment
ATM	atmospheric transport models
AusAID	Australian Agency for International Development
AVHRR	Advanced Very High Resolution Radiometer
BAKORNAS PB	Badan Koordinasi Nasional Penanggulangan Bencana (National Coordination Agency for Disaster Management)
BAPEDAL	Badan Pengendalian Dampak Lingkungan (National Environmental Impact Management Agency)
BAPPENAS	Badan Perencanaan Pembangunan Nasional (National Development Planning Agency)
BMG	Badan Meteorologi dan Geofisika (Meteorological and Geophysics Agency)
CDC	Centre for Disease Control (Malaysia)
CIDA	Canadian International Development Agency
CIFOR	Centre for International Forestry Research
COST	ASEAN Committee on Science and Technology
CRISP	Center for Remote Imaging, Sensing and Processing
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSU	Coordination and Support Unit
DIP	Detailed Implementation Plan
ENSO	*El Niño* Southern Oscillation
ENSOI	*El Niño* Southern Oscillation Index
EPA	US Environmental Protection Agency
ESCAP	Economic and Social Commission for Asia and the Pacific
EU	European Union
FAO	Food and Agriculture Organization
FDRS	fire danger rating system
FFPCP	Forest Fire Prevention and Control Project (of the EU)
FFPMP	Forest Fire Prevention and Management Project (of JICA)
FIRE	Fire in Global Resource and Environmental Monitoring (CEC-JRC)
FSMP	Fire Suppression Mobilization Plan

GAW	Global Atmospheric Watch
GDP	gross domestic product
GIS	geographic information system
GMS	Geostationary Meteorological Satellite
GTZ	Deutsche Gesellschaft fur Technische Zusammenarbeit (German Agency for Technical Cooperation)
ha	hectare
HTTF	Haze Technical Task Force
ICRAF	International Centre for Research in Agroforestry
IDNDR	International Decade for Natural Disaster Reduction
IFFM	Integrated Forest Fire Management Project (of GTZ)
IFFN	*International Forest Fire News*
IGAC	International Global Atmospheric Chemistry
IMS	information management systems
JICA	Japan International Cooperation Agency
KBDI	Keetch-Byram Drought Index
km	kilometer
LAPAN	Lembaga Antariksa dan Penerbangan Nasional [Indonesian National Institute of Aeronautics and Space]
m^3	cubic meter
MACRES	Malaysian Centre for Remote Sensing
mm	millimeter
MOFEC	Ministry of Forestry and Estate Crops (Indonesia)
mt	metric ton
NDVI	Normalized Difference Vegetation Index
NWFP	nonwood forest product
NWP	Numerical Weather Prediction
NGO	nongovernment organization
NHAP	National Haze Action Plan
NMS	National Meteorological Services
NMSs	nonmeteorological satellites
NOAA	National Oceanic and Atmospheric Administration
ORHAP	Operationalized Regional Haze Action Plan
PARTS	Programme to Address Regional Transboundary Smoke
PM	particulate matter
PRC	People's Republic of China
PSI	Air Pollutant Standard Index
PMU	Project Management Unit
PUSDALKARHUTNAS	Pusat Pengendalian Kebakaran Hutan Nasional (National Center for Forest Fire Control)
RETA	regional technical assistance
RHAP	Regional Haze Action Plan

RFA	Regional Firefighting Arrangement
SEA-EI	Southeast Asian Environment Initiative
SEAFIRE	Southeast Asian Fire Experiment
SOP	standard operating procedure
SPOT	Satellite Positioning and Tracking
SRFA	Subregional Firefighting Arrangement
STARE	Southern Tropical Atlantic Regional Experiment (IGAC)
TEWT	Tactical Exercise without Troops
TKNPKHL	Tim Koordinasi Nasional Pengelolaan Kebakaran Hutan dan Lahan (National Coordinating Team for Land and Forest Fire Control Management)
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNDAC	United Nations Disaster Assessment and Coordination
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations Children's Fund
US	United States
USAID	United States Agency for International Development
WHO	World Health Organization
WMO	World Meteorological Organization
WRI	World Resources Institute
WWF	World Wide Fund for Nature

Note: "$" refers to US dollars unless otherwise specified.

Executive Summary

Background

In recent years, forest fires influenced by rapid demographic changes, increased human activity, and unpredictable climatic variability have become a major environmental problem in the tropical ecosystems of the Association of Southeast Asian Nations (ASEAN) region. Fires and associated haze have adversely affected the natural environment and threatened the sustainable development and management of natural resources. Hence, fire and haze management has acquired a new dimension in land resources and environmental management that must be accorded urgent and utmost attention. The problem and the causes if not addressed urgently may not only affect the countries in the region, but its many impacts may also extend beyond and acquire global dimensions.

Early humans used fire as a tool to alter their surroundings and later to prepare land for cultivation. The use of managed fires became a common practice in land conversion. However, once out of control due to negligence, carelessness, or arson, the fires led to long-term land degradation and resulted in other detrimental impacts, to the ultimate disadvantage of human society.

Every year, millions of hectares of the world's forests are being consumed by a large number of fires, big and small, resulting in billions of dollars in suppression costs and causing tremendous damage in lost timber, declines in real estate and recreational values, property losses, and deaths. Wildfires have influenced many aspects of our life: the flow of commodities on which we depend, the health and safety of the communities where we live, and the resilience of our natural ecosystems.

Southeast Asian Fires and Haze

Tropical rain forests are the natural vegetation in large areas of Southeast Asia. These forests grow under conditions of abundant rainfall, high temperature, and humidity, rendering them less vulnerable to fires and more resistant to burning.

Wildfires in Southeast Asia since the Pleistocene age were made possible only by periods of reduced rainfall, long enough for rain forests to become dry and vulnerable to burning. In the Ice Age, extended periods of minimal rainfall occurred in Southeast Asia, making large areas of the region vulnerable to fires. Only recently, long-term climate variability, i.e., glacial vs. nonglacial climate and short-term climate oscillations caused by *El Niños*, have regularly created conditions that make even the rain forests vulnerable to wildfires. Forest and landfires are also linked to human interventions.

Humans have used fires as they settled in the forests for thousands of years to practice swidden agriculture and to help in hunting. Traditional use of fire is thought to have little long-term ecological impact on the forests; but increased population density, shortened fallow periods, and cash cropping made shifting cultivation an agent of ignition, along with several other factors.

Since 1982, there have been five major fire outbreaks in Southeast Asia, with small fires occurring almost annually. The last major fire was in 1997-1998, destroying an estimated land and forest area of more than 9 million hectares (ha) in Indonesia alone.

Underlying Causes

Availability of dry fuel, a source of ignition to set fire, and a transport mechanism such as wind to feed a conflagration are the main factors behind all major forest fires and associated haze. Three factors enhance the magnitude of such occurrences: direct and immediate causes, contributing factors or constraints, and indirect or influencing factors.

Direct Causes

Most tropical fires are set or spread accidentally or intentionally by humans and are related to several causative agents; some of them linked to subsistence livelihood, others to commercial activities. Foremost among the various underlying causes of catastrophic fires in Southeast Asia in 1997-1998 are the use of open burning techniques for conversion of forestland to other land uses, e.g., estate crops, industrial plantations, and other commercial enterprises; traditional slash-and-burn agriculture; and speculative burning to stake land claims.

According to a study conducted by the Ministry of State for Environment in Indonesia,* the fires and haze of 1982-1983, 1987, 1994, 1997, and 1998 were due to a wide range of factors. These include:

(i) lack of institutional commitment at regional, national, provincial, and local levels to make investments in preventing land and forest fires as opposed to mitigation;

(ii) increased vulnerability of forestlands to fires from unsustainable forest management and harvesting practices;

(iii) conflicting roles and responsibilities of institutions concerned with managing forestlands and forest fires, especially on the mandate, authority, financial resources, and accountability;

(iv) indifference to the cyclical nature of fires and haze in the region on the part of institutions charged with managing forestlands and forest fires, and disregard for early warning announcements on the onset of *El Niño*;

(v) inadequate information and systems for communication, including ineffectiveness of such systems from institutional failure;

(vi) vested interests that marginalize issues relating to fires and haze to favor a particular sector, corporate body, or individual;

(vii) lack of incentives to promote logging techniques that lead to sustainable output of production forests, and mechanical land clearing;

(viii) inadequate research into the use of logging residues as productive inputs and development of logging products;

(ix) indifference of the private sector (industry, large-scale agriculture, and smallholders) to the environmental consequences of large-scale fires;

(x) poorly specified property rights that caused mutual conflicts among numerous classes of land claimants (local residents, government, transmigrants, industry);

(xi) indifference of government and entrepreneurs to local customary rights, livelihood strategies, and traditions that eroded customary law, social cohesiveness among indigenous groups, and traditional knowledge regarding prevention and control of fires;

(xii) inadequate knowledge of fire prevention and mitigation techniques exacerbated by a lack of operating procedures and appropriate institutional arrangements for coordinating mitigation activities at the national, regional, and international levels;

(xiii) inadequate prevention and mitigation capacity, i.e., trained personnel, equipment, and facilities at the regional, national, and local levels; and

(xiv) inadequacy or nonexistence of committed funding for prevention and mitigation activities at the regional, national, provincial, and local levels.

Contributory Factors

Apart from direct causes, there are contributory factors that increase the potential of fire danger. These include political, economic, physiographic, sociocultural, and institutional factors. In fact, the most important of these are policies and institutions.

Lack of political will, inappropriate and poorly specified policies, weak legislation, ambiguous regulations, bureaucratic procedures, land-use conflicts, and inadequate resources for enforcement of laws and regulations were again and again crucial and crippling constraints. Policy gaps and conflicts in land use, tenure security, and economic development add considerably to the dangers posed by forest fires.

Indirect Factors

Indirect and influencing factors such as climate and climatic variation often play a significant role in the setting off of forest fires and associated haze. Climate is an overriding control factor in fire occurrence and frequency. It determines not only the vegetation characteristics in a general sense, but also influences soil microorganism activity and thus the litter decomposition. In tropical lowland environments,

*Ministry of State for Environment, Republic of Indonesia and United Nations Development Programme. 1998. *Forest and Land Fires in Indonesia*. Volumes I and II.

litter decomposition is generally fast, and organic matter accumulation is rarely an important factor. However, climatic seasonality in terms of wetness and dryness is the most important parameter related to fire occurrence. In tropical conditions where seasonal changes are less evident, the weather variations due to climatic disturbances lead to cyclical drought conditions.

Meteorologists consider *El Niños* as one of the significant aggravating factors behind the rise in temperatures and consequent drought in Southeast Asia during major fires and haze in the past years. *El Niños* are an oceanographic phenomenon of strong and extensive warming in the upper ocean of the tropical eastern Pacific. An *El Niño* arises, periodically, to upset global weather patterns. *El Niños* lead to the strengthening of a warm ocean current called the equatorial counter-current in the mid-Pacific, causing the entire weather mechanism to be disrupted. Rainfall is delayed, crops are adversely affected, and storms occur where they should not.

Investigators of the fires and haze in Southeast Asia indicated that while the *El Niño* phenomenon created dry conditions, the direct causes of the damaging fires were habitual use of uncontrolled, open, and broadcast fires as cheap means of land clearing and preparation by owners of plantations; small farmers; and slash-and-burn agriculturists.

Impacts

Burning of forests and biomass has serious impacts, often resulting in loss of life, livestock, and capital. The damage caused by fires is often difficult to quantify, especially when nontangible losses are involved. Impacts of forest fires have several dimensions—economic, environmental, ecological, social, and others that could be onsite and offsite, direct and indirect.

The extent of impacts would depend on the frequency and intensity of fires, fuel load, type of forests involved, and climatic factors.

Human interventions make tropical forests far more vulnerable to fire than otherwise. The greater the degree of human intervention into the natural tropical forest ecological system, the more vulnerable these forests become to fire. This conclusion has obvious implications for conversion of natural forestland to other uses. The Indonesian Ministry of State for Environment Report quoted earlier provides fresh empirical evidence that supports the above conclusion. According to the report, of a total area of 4.8 million ha consumed by fire in 1994, 88 percent comprised logged-over forests or land under cultivation by traditional dry land agricultural techniques.

In contrast, shifting cultivation accounted for only 5 percent, transmigration farmland 4.5 percent, plantations only 0.8 percent, and natural protected forests a scant 0.2 percent. The figures for 1997 tell a similar story. Of all land area consumed by forest fires during the year, logged-over production forests accounted for 62 percent. The remainder comprised the national parks, 20.6 percent; protection forests, 8 percent; nature reserves, 6.5 percent; and recreation parks, 0.6 percent.

Economic Impact

An estimated spatial distribution of areas affected by 1997-1998 fires included more than 6 million ha in Kalimantan, more than 1.5 million ha in Sumatra, some 1 million ha in Irian Jaya, about 400,000 ha in Sulawesi, and about 100,000 ha in Java. Of the burned area, 4.65 million ha is forestland.

The economic loss has been estimated to be about $6 billion. This does not include the full environmental costs, e.g., loss of biodiversity or the cost of social suffering.

Apart from the loss of material goods and services, forest fires have caused serious direct economic losses through damage and decline in the quality of forest growing stock, reduced landscape stability, increased proneness to pests and diseases, reduced availability of forest-based raw material supplies, and the need for new investments in forest rehabilitation and fire protection measures. Indirectly they have affected agricultural productivity and tourism.

They have also had an impact on indigenous populations and their means of livelihood, and jeopardized the prospects and ability of the rural poor to improve their standard of living.

Forest fires have also degraded surviving forests by exerting potential impact on composition, regeneration, productivity, protection functions, and aesthetic values.

Ecological and Environmental Impacts

Ecological impacts of forest fires are reflected in the degradation of vegetation quality, expansion of savannah and sterile grasslands, erosion of biodiversity, damage to the health of the forest ecosystem, plant mortality, loss of wildlife habitat and wildlife, pollution in rivers and estuaries, and overall ecological retrogression. Fires affect the quality and productivity of soil by destroying humus and altering its chemistry, increasing soil temperature, destroying microbial inhabitation, reducing moisture retention capacity of the soil, causing erosion of surface soil and nutrient loss, increasing run-off, lowering the subsoil water table and causing desertification, and ultimately, reducing the carrying capacity of the land involved.

Forest fires contribute to global climate change and warming. Burning of forests destroys an important sink for atmospheric carbon, while biomass burning is recognized as a significant global source of emissions, contributing as much as 10 percent of the gross carbon dioxide and 38 percent of tropospheric ozone.

Haze formation and dispersion have important environmental dimensions that include air pollution both within boundary and transboundary. Other effects include reduced visibility, transport disruption, and health hazards. Apart from public health, social welfare is adversely affected through displacement of communities, loss of income sources, and dwindling livelihood opportunities.

Responses

Global Concern

The recurrence of increasingly large forest fires has attracted world concern, particularly in the industrialized countries, for the last several years. In those countries, fire science and technology have developed considerably and sophisticated systems are being employed to forecast and monitor fires and haze through the use of satellite and space-borne sensors, and climate and transport models. Some of these new technologies are being transferred to tropical developing countries, but considerable efforts are required to balance and tune them to their needs.

The increasing frequency and intensity of fires and haze are alarming and have led to several parallel initiatives globally. The Antalya Declaration of the Sixteenth World Forestry Conference in 1997 highlighted the urgent need for improved and integrated forest fire management.

ASEAN Response

The major haze source countries in the region affected by the 1997-1998 fires have experienced similar occurrences during the last 20 years. Despite these, their capability to adequately respond to the situation has not matched the needs. In this connection, ASEAN has assumed the central role. For several years ASEAN was concerned with the issue of transboundary atmospheric pollution in the region and some general instruments have been put in place.

Regional Haze Action Plan

Intergovernment efforts of the ASEAN member countries (AMCs) to address transboundary atmospheric pollution, in the wake of the 1997 forest fires and haze, resulted in the Regional Haze Action Plan (RHAP), approved for implementation in December 1997. The primary objectives of the RHAP are to: (i) prevent forest fires through better management policies and enforcement, (ii) establish operational mechanisms to monitor land and forest fires, and (iii) strengthen regional land and forest firefighting capacity with other mitigation measures.

The RHAP has three major component programs: prevention, mitigation, and monitoring. Different countries have been designated to spearhead the activities that fall under each of the three RHAP programs. Malaysia takes the lead in prevention, Indonesia in mitigation, and Singapore in monitoring of fires and haze. All AMCs will undertake the national-level actions of the three RHAP programs. Prevention, mitigation, and monitoring will also take place at the subregional and regional levels. A considerable amount of donor assistance was forthcoming for this crucial initiative, in which the Asian Development Bank (ADB) played a catalytic role.

Role of the Asian Development Bank

The RHAP was signed during a period of intense fire, smoke, and transboundary pollution. It was formulated and endorsed within an abbreviated time frame, so it was not possible for the ASEAN Ministerial Meeting on Haze (AMMH) or the Haze Technical Task Force (HTTF) to work out the implementation details prior to endorsement by the nine AMCs. What the Ministers had in mind when they endorsed the RHAP document was to initiate a *process*.

The document had also made it clear that ADB's assistance would be sought to implement the plan. ADB's response to the requests of ASEAN was fast and firm. It adopted a two-pronged approach, in the form of regional and national initiatives.

The regional technical assistance (RETA) 5778: *Strengthening the Capacity of the ASEAN to Prevent and Mitigate Transboundary Atmospheric Pollution*; and advisory technical assistance (ADTA) INO 2999: *Planning for Fire Prevention and Drought Management* were approved in early 1998. Implementation of these technical assistance grants has been completed.

The focus of ADB's RETA Project was to strengthen ASEAN's capacity in operationalizing and implementing the RHAP. The complementary ADTA was designed to estimate the economic damage caused by the 1997-1998 fires in Indonesia, to provide a basis for policy change, and identify investments needed for prevention and mitigation of forest fires at the country level.

The main objective of the RETA Project was to strengthen and formalize cooperation among ASEAN countries affected by forest fires and haze by supporting the

- short-term measures aimed at operationalizing the RHAP;
- medium-term measures to strengthen the capacity of relevant institutions in implementing the RHAP, and improve scientific understanding of large-scale fires and transboundary atmospheric pollution; and
- strengthening the capacity of institutions to implement and institutionalize the RHAP.

These called for several actions to achieve the following:

- identify actions to be taken by the AMCs to establish an institutional framework to address the region's transboundary haze pollution problem on a long-term, sustainable basis;
- decide the required investments, if any, to support the institutional framework;
- catalyze donor collaborative partnerships and activities to directly complement the AMCs' planning in confronting the region's transboundary haze pollution problem;
- share knowledge and experience as well as efficient and economic use of regional firefighting equipment;
- develop formalized cooperation arrangements among countries of the region and beyond, to enhance scientific understanding of the causes and consequences of transboundary atmospheric pollution; and
- establish a regional level framework for joint response mechanisms through enhancement of ASEAN and associated institutions' capacity in the effective implementation and monitoring of the RHAP.

One of the prime needs was to channel all efforts, whether funded by the AMCs, ASEAN, or international assistance agencies, through an operational network of national, subregional, and regional arrangements. The RETA Project was able to do this effectively, particularly obtaining donor resources for the implementation of RHAP components.

In tandem with the inception workshop of the RETA Project, an open forum for donor's participation in assistance for fires and haze was held in early 1998. This led to a number of commitments complementing the RETA Project activities, and taking over of some activities within the Project's scope. Resources were utilized for important underfunded activities. The assistance of Australia and the United States in implementing the World Meteorological Organization (WMO) program to address the regional transboundary haze as well as United Nations Environment Programme (UNEP) support in various areas of fires and haze mitigation deserve special mention.

Achievements of the RETA Project

The RETA Project's achievements through direct intervention and collaboration with other donors were gratifying. These include the following.

A. Through direct intervention:

- Compiled baseline information through surveys, studies, and assessments.
- Conducted an inventory of the regions' firefighting resources and fire suppression capabilities.

- Established and strengthened subregional firefighting arrangements.
- Carried out studies and evaluations on ASEAN's existing forest fires and haze monitoring system to promote their upgrade.
- Undertook policy studies on the use of market-based instruments to promote adoption of mechanical zero-burn land clearing methods and marketing of products using biomass residues as productive inputs.
- Reviewed national and international laws, policies, and institutional arrangements connected with forest fire and haze issues and developed a legal framework and facility for cross-border cooperation.
- Helped to develop regional and national facilities for fire and haze monitoring, e.g., ASEAN Specialized Meteorological Centre (ASMC).
- Developed and strengthened the system of information management at the ASEAN level and supported the establishment of a regional information center and clearinghouse, which included the setting up of ASEAN Haze Action Online.
- Assisted in operationalizing a RHAP that includes a system of detailed implementation plans at the regional, subregional, and national levels.
- Assisted in organizing institutional mechanisms, particularly for regional coordination, through the establishment of a Coordination and Support Unit.
- Promoted a continuous dialogue among ASEAN members and partners as an ongoing system for effective regional cooperation.

B. Through collaboration with other donors:

- Formulated an operating procedure for activating forest firefighting resources in the ASEAN region, with particular reference to Indonesia.
- Designed a model fire suppression mobilization plan and initiated the preparation of Fire Suppression Mobilization Plans (FSMPs) for specific areas.
- Conducted studies on haze transport and climate models and harmonization of pollution indexes.
- Catalyzed and collaborated in conducting studies on health impacts of haze pollution.
- Promoted development of facilities for training and research studies relating to forest fires and haze management.
- Mobilized donor support for fire-and-haze-related projects, e.g., program to address regional transboundary smoke (PARTS), forged collaborative partnerships with other international institutions, and facilitated donor coordination.

Operationalized Regional Haze Action Plan (ORHAP)

The prime output of the RETA Project was an operationalized version of the RHAP (ORHAP), which was approved for implementation by the ASEAN Senior Officials on Environment and HTTF in July 1999. ORHAP had two major beneficial impacts on ASEAN. First, it helped ASEAN to address the fire-and-haze issue directly, with actions that increase the region's capacity to manage future forest fires and haze. It also catalyzed the beginning of ASEAN's reorientation from a passive agency that responds to challenges in an ex post manner to a more forward looking institution that anticipates challenges and responds to them ex ante.

The programs and activities of the ORHAP are defined considering three basic parameters:

- the region's transboundary pollution problem is ultimately driven by national-level policies;
- haze pollution itself results from behavior heavily reinforced by profit considerations; and
- climate factors act to worsen the tendency of the above two parameters to produce haze.

And five strategic considerations:

- the primary goal of the ORHAP is to prevent the recurrence of transboundary haze and this calls for a focus on fire management;
- endorsement of the RHAP and ORHAP by an ASEAN country implies limitations on land conversion;
- measures in the ORHAP that remove or address "binding constraints" on preventing or mitigating transboundary haze pollution will be given highest priority. Measures that address successively less binding constraints will be assigned successively lower priority.
- the purpose of ORHAP-related measures at regional and subregional levels is to catalyze and complement,

rather than to substitute for, the measures carried out at the national level; and

- wherever alternative measures for achieving the same objective exist, the one that costs less will be implemented.

The ORHAP is designed as a rolling plan with a short-term horizon, to be updated annually, i.e., a detailed implementation plan for year one plus a regular ORHAP for the succeeding five years. Thus, the ORHAP is a document meant to be continually refined and updated. Depending on the evaluation of activities conducted and completed in the previous periods, future activities can be modified, new activities added, and redundant ones deleted. These additional activities are expected to be of two types: those undertaken directly by the AMC governments themselves and those for which donor support will need to be catalyzed.

The three major programs of ORHAP: prevention, mitigation, and monitoring were divided into 20 activities and 50 actions. To implement these programs, the ASEAN region was subdivided into member countries, and each AMC had its own system of provinces, districts, etc. The country plan, including subplans on fires and haze includes the National Haze Action Plans (NHAPs), with the countries free to adopt their own program structure. The NHAPs are linked to the ORHAP. As in the case of programs, there could also be parallel linkages due to overlapping of interests or other expediency criteria. The two Subregional Firefighting Arrangements (SRFAs) (Borneo and Sumatra) within the umbrella of the ORHAP are cases of parallel spatial linkages at subregional level in respect of a program activity, i.e., firefighting. Spatially, nine NHAPs and two SRFAs are appropriately linked.

Detailed Implementation Plan

The core of the ORHAP is a Detailed Implementation Plan (DIP), which contains the provision for actual implementation of activities. Each DIP is prepared based on commitments from the AMCs, assistance agencies, donor countries, nongovernment organizations (NGOs), community groups, and other voluntary organizations.

In addition to detailing the organization and designating the persons responsible for each action, the DIP also presents a detailed matrix of the budget, source of funding, time frame, and a monitoring variable to determine the successful implementation of actions. Thus the DIP matrix can function also as a vehicle for monitoring ORHAP implementation. Transparency in monitoring is assured by dissemination of the entire DIP matrix to all concerned parties by a restricted access, i.e., password-required, intranet.

While the ORHAP details the steps that ASEAN itself will take, donor-assisted initiatives only support the steps taken by ASEAN. The full complement of concrete measures that will comprise the implementation strategy also need to be laid out.

Since the actions are undertaken at regional, subregional, and national levels, correspondingly, the DIP is divided into three. The DIPs relating to various levels together comprise the ORHAP DIP, which collectively form the detailed "to-do" list that guides implementation over six years. The ORHAP is thus composed of one regional, two subregional, and nine national DIPs.

At the ASEAN level, HTTF will monitor the progress of ORHAP implementation and take action in shaping the region's infrastructure for fire protection and mitigation. A brief description of the three major programs follows:

Prevention

While the program defines its scope, funding determines the actual number of incorporated activities. Accordingly, the first six-year rolling ORHAP include 10 activities:

- forecasting climatological conditions that are likely to result in fires and haze;
- mapping areas subject to heightened risk of forest fires, including how these at-risk areas expand or shrink in response to seasonal, annual, or multi-year changes in climate;
- managing and disseminating information on fires and haze, the geographical areas that may be affected by haze, and the human health impacts or likely impacts of existing or forecasted haze presence or movement;
- reviewing the existing policy framework at the national level to determine how the economic incentives that it

provides are likely to shape the use of fire as a tool or weapon;

- bringing about appropriate policy changes to ensure that the economic incentives provided by the policy framework at the national level are consistent with the policy on open burning;
- providing market-based and other economic incentives for promoting the adoption of new products and technologies that use biomass, logging, and land-clearing residues as productive inputs;
- formulating, operationalizing, and implementing NHAPs as a foundation to operationalize the RHAP, and increase the degree of readiness to meet forest fire emergencies at the national level;
- harmonizing and integrating NHAPs at the ASEAN level to ensure collective consistency and effectiveness in jointly responding to regional forest fires and haze;
- developing and implementing institutional arrangements for linking national firefighting capabilities in any combination within ASEAN, e.g., SRFAs, or other mechanisms for coordinating multiple national firefighting capabilities; and
- formulating, ratifying, and implementing an ASEAN-wide Forest Fire Readiness Protocol that formalizes national-level firefighting linkages by putting into place institutional arrangements that facilitate rapid deployment.

In the context of the ORHAP, prevention signifies control of transboundary haze pollution and related damage, both environmental and material, to the fullest extent possible. It involves efforts on two fronts:

- preventing fires from outside, e.g., agricultural areas, burning forests and other natural vegetation; and
- managing the use of fire for land clearing and refuse disposal so that the extent and density of burning are controlled.

Fires should be prevented as much as possible, since control and mitigation is more difficult and expensive. Prevention is one of the most effective ways of tackling land and forest fires. Management of the land conversion process needs to be addressed through policy and regulatory measures. The prevention of land and forest fires embraces a wide range of measures that either modify the fuels found within or around the fire-threatened resources to reduce the spread and intensity of fires, or reduce the chances of human-caused ignition.

Various categories of fire prevention measures include scientific resource management, policy reforms and modifications, command and control, public education, and moral suasion.

Scientific forest resource management regarding fires comprises hazard reduction measures, including rational and controlled use of fire, such as prescribed burning. Forest fire management can be an important aspect of sustainable forest management practices to ensure that negative impacts are minimized and positive impacts maximized.

Policy measures involve removal of anomalies in the existing land conversion and related policies, improving the policy environment with nondistortionary incentives, and introducing zero-burn land-clearing systems and market-based instruments.

The regional project carried out a special study on the potential of promoting mechanical land clearing and marketing of products based on residues. It noted that the technical feasibility of zero-burn land-clearing methods has been proven and demonstrated in a number of cases in the region. It was the skewed system of incentives involved in the free use of open fire for land clearing and the landowners' efforts to maximize private profits that created doubts about its economic advantages. From an overall national and socioeconomic point of view, the system has several merits. In Sarawak, Malaysia, land clearance for cultivation is mostly carried out mechanically and land preparation for planting follows "zero-burn" methods.

Market-based instruments or approaches can be applied in several variations to encourage land clearing through zero-burn techniques and to promote products that use the biomass resulting from mechanical land clearing as raw material. The exact extent and conditions under which zero-burn land-clearing techniques are financially feasible or applicable are still being worked out. However, available evidence suggests that these conditions are likely to vary widely. What is certain is that in some haze-source ASEAN countries, explicit and implicit subsidies for land clearance reward the use of open burning. For environmentally conscious operators, the existing indirect subsidies act as a strong disincentive to the use of zero-burn methods. The incentive system, thus, subsidizes the behavior that contributes to transboundary haze pollution and penalizes the behavior that attempts to prevent it. The use of market-based instruments will partially remove the two-edged bias against the use of mechanical land-clearing techniques.

The rationale for market-based instruments is to prevent people from using fire as a land-clearing tool for their own motives at little cost, shunting the bulk of the burden to haze-recipient populations. On the other hand, operators using mechanical land-clearing techniques bear all of the costs of land-clearing. Thus, even if open burning was not subsidized, the operator using open burning enjoys more profit than the operator using mechanical land-clearing techniques. Allowing this is inconsistent with economic efficiency and market principles where producers compete on an equal footing so that society can obtain products at the lowest possible cost. If for any reason this equal footing is weakened, damaged, or destroyed, society-at-large is the loser. The introduction of market-based instruments promotes competition on an equal footing and brings about economic efficiency with society as a whole benefiting.

Command and control is an expression to cover all legal measures including instruments, regulatory mechanisms, legal sanctions, and restrictions. Legal measures form an important fire prevention tool. Command-and-control measures directly regulate human use of fire by imposing sanctions against persons who use it in unapproved ways. Command-and-control measures are therefore implementable only at the national or subnational level. Nonnational entities at the regional and subregional levels can play a role in facilitating or supporting implementation of command-and-control measures at the national or subnational levels.

Public education and moral suasion objectives can be achieved through dissemination of information and use of the media. Public education and awareness programs reduce transboundary haze pollution by informing stakeholders of the broader negative effects of open burning and haze pollution. Once they are made aware of these effects, at least some of these stakeholders will limit open burning or even stop this practice altogether. ASEAN will therefore promote such new programs and expansion of existing ones in all member countries by sponsoring workshops and training programs, especially in key fire-and-haze-prone areas.

Moral suasion initiatives reduce transboundary haze pollution by publicly informing stakeholders who are tempted to practice uncontrolled open burning of the broader negative effects of the practice. ASEAN undertakes such initiatives by meeting directly with representatives of relevant private sector firms as appropriate, and discussing the broader negative impacts of uncontrolled open burning and transboundary haze pollution.

Mitigation

To reduce the impacts of fires and haze, mitigation calls for action at three stages: pre-event, during the event, and post-event. These three stages consist of the following activities: (i) preparedness to face fires where actions on infrastructure, equipment, strategies and logistics, training, crew fitness, surveillance, etc., are planned and implemented; (ii) suppression, including aspects of detection, quick communication of information, crew mobilization and dispatch, provision of water, movement of equipment, coordination of field action, e.g., of aerial and ground operations, firefighting, and extinguishing of fires; and (iii) relief to those affected by haze pollution and fires, including medical attention and compensation, and rehabilitation to repair damage to property and resources.

Mitigation is closely linked with other ORHAP programs. Prevention, e.g., firebreaks, fuel load control, other preventive measures, and monitoring includes weather monitoring, fire modeling, fire spotting, and early warning. Many of the time-consuming operations are carried out when there is apparently no fire danger. For example:

- developing and maintaining infrastructure, water storage, firebreaks and fire corridors, aircraft landing sites;
- acquiring, maintaining, and stock verification of tools and equipment, e.g., hand tools, heavy equipment, water hoses and tankers, communication equipment, etc.;
- preparing and revising fire maps, information materials, guidelines, and instructions for crew;

- planning for fire emergencies, covering strategies and logistics;
- establishing fire detection, surveillance, i.e., aerial and ground, and intelligence systems;
- preparing resource mobilization plans;
- contacting community leaders, cooperating agencies, and volunteers;
- conducting training and retraining for various levels;
- reviewing, modifying, or improving organizational arrangements, and standby and response orders; and
- conducting dry runs and intensive drills, and keeping the crews in good shape.

The activities are carried out as per plan to keep the whole system in a "well-oiled" condition, and ensure that no details are overlooked and "the war is not lost for want of a nail." Two important initiatives to promote "better preparedness" undertaken during the execution of the RETA Project, and still continuing, were: (i) preparation of a system of FSMPs; and (ii) establishment of working groups for SRFAs.

FSMPs are required to start from the village level and move upwards through the institutional hierarchy, to be linked at district, provincial, and SRFA levels to ensure an effective functioning system.

When the process of formulating or upgrading FSMPs for various areas is completed, a database containing all relevant information such as the training and equipment requirements, operational costs of implementing the FSMPs, and inventory of skilled personnel and equipment needs to be assembled. This must be carried out individually for each geographic area, and the results aggregated at the national level. Regular and continuous updating of this database would ensure better utilization at the time of need. The government agency performing this task at the national level should be assigned the lead role in fire management.

SRFAs: The main rationale for subregional cooperation in fire management and suppression is cost effectiveness. One means of increasing the cost effectiveness of fire suppression at the national level is by risk pooling at the international level. This involves supranational sharing of fire suppression resources during periods of peak demand.

Because the risk of large-scale fires occurring simultaneously in all countries in a regional or subregional grouping is slight, resources on standby in a member country not threatened by fire can be used to augment those in places where fire suppression resources are fully employed.

Since the overall risk of transboundary haze and the fires that cause them is so unevenly spread across the region, the subregional level is the key in organizing and carrying out cooperative mitigation-related activities under the ORHAP. The same is true with monitoring activities.

Two SRFAs are in place. SRFA Sumatra's membership comprises Indonesia as lead country, Malaysia, and Singapore. SRFA Borneo's membership comprises Brunei Darussalam as lead country, Indonesia, and Malaysia. A third SRFA for the Greater Mekong subregion (SRFA-GMS) has yet to be officially formed, because the impetus for this, i.e., extensive large-scale fires within the area, has not yet arisen. SRFA-GMS would group all AMCs through which the Mekong River flows: Cambodia, the Lao People's Democratic Republic, Myanmar, Thailand, and Viet Nam. Its formation would leave the Philippines as the only ASEAN country not a member of an SRFA. This deficiency could easily be repaired by the Philippines joining SRFA Borneo, which would be fitting, because of the country's proximity to Borneo.

ORHAP activities to be carried out at the subregional level must avoid violating an individual member country's national sovereignty in two key areas. First, the requesting country only may trigger the physical entry of fire management personnel and equipment from one member country into another's territorial boundaries. The host country alone must decide when the threshold at which large-scale fires can no longer be contained by national fire management resources has been breached, and suppression resources drawn from the supranational level will be required to prevent haze from violating another country's airspace.

Second, the deployment of suppression resources drawn from the supranational level must take place on the basis of an agreed subregional FSMP, rather than on an ad hoc basis improvised at the spur of the moment. The subregional FSMP should, as a first step, work out logistics for efficient deployment of national fire management resources. Only then should deployment of supranational resources be integrated into the national level framework.

The ORHAP's mitigation program has identified four priority activities for the first six years of the rolling plan: (i) formalizing arrangements for improved training and retraining of forest firefighters at the national and regional level to ensure that trained personnel are adequately equipped to cope with future forest fires; (ii) inventorying existing firefighting capability at the national level, including all aspects of equipment and personnel, to determine the maximum scale of forest fire that existing resources are equipped to handle; (iii) strengthening firefighting at the national level where each AMC's capability is sufficient to cope with forest fires likely to occur on an annual basis; and (iv) ensuring the continued readiness of firefighting capability at the national level through regular maintenance of equipment and upgrading of skills of firefighting personnel.

Monitoring

There are large variations in the scope, methods, types, purposes and objectives, and outputs of monitoring. Monitoring can be an event, a process, or an output; it can be discreet, continuous, or incremental; it can be tackled directly, indirectly, or by proxy measures; it can be done from ground (site) or air (remote).

It can employ simple methods or measures, i.e., number, area, volume, profit or sophisticated technology involving satellites, computers, and systems science providing for multiple linkages, e.g., weather data, economic data, management information system, geographic information systems, and facilities to import and export information.

The data needs of sophisticated monitoring systems are often tremendous, ranging from land-use changes and demographic trends to socioeconomic indicators, hydrometeorological factors, spatial and temporal distribution of relevant factors, and environmental standards.

While the ORHAP has defined the scope of monitoring based on the needs and priorities of the region, six activities were included in the ORHAP's current monitoring program, including:

- detecting wildfires;
- predicting and tracking the movements of the resulting haze;
- forecasting the degree of wildfires likely to generate haze, as well as the type or composition of emissions that might be generated;
- determining the likely health impacts from typical or particular haze;
- identifying the areas historically affected by forest fires and haze in the region, or those likely to be affected by particular occurrences; and
- assessing the impact of past forest fires, including the extent of area burned, the composition of flora and fauna destroyed, and the socioeconomic cost of particular forest fires at the local, national, and global levels.

The scope of monitoring of fires and haze covers early warning and fire danger rating, large-scale fire management assistance, atmospheric pollution, and health impacts of haze and *ex-post* monitoring.

Early warning system. The early warning system aims to provide a measure of the risk of fires and to communicate the information in a timely manner to the central, provincial, and district authorities and the community as a whole. Fire danger warning is probably the central function of a fire monitoring system, and most other activities are, in one way or the other, related to this important aspect. Simplicity is the primary hallmark of any early warning system. The warning system is based on climate models and forecasting of weather trends. The *El Niño* Southern Oscillation index is a useful predictor of fire weather in the region.

Nearly all fire danger rating systems incorporate three base weather variables: rainfall reflecting wetness or dryness, relative humidity, and maximum temperature. More sophisticated indexes add fuel types and land use classification to the base weather variables.

Relative humidity and maximum temperature remain relatively uniform in the parts of the ASEAN region affected by forest fires over the past two decades. They are thus poor predictors of fire activity. Neither are the data on fuel types particularly helpful, since the purpose of deliberate open burning is to consume whatever fuel is present. Therefore, there is need to develop a fire danger index that is most appropriate to the situation in the ASEAN region. Efficacy of different systems such as the Keetch-Byram Drought Index (KBDI), Rainfall Debt, and the Canadian Fire Weather Index in their modified forms have been assessed. However, a decision on a common fire danger index for the region is yet to be taken.

Large-Scale Fire Management Assistance. If a wildfire occurs in spite of the early warning system and the preventive measures taken, the monitoring system should be able to detect the fire and begin tracking changes in its status. The system should determine first the precise location of the fire so fire management resources can be deployed quickly to the fire site. It should then track any spread of the fires and resulting haze, thereby assisting national and regional authorities in managing the fire and in activating any preestablished haze response systems. The important technical activities that comprise an appropriate fire-and-haze detection and tracking system include intensive surveillance and haze transport modeling. The regional and national capabilities in this regard are being enhanced through international assistance.

Atmospheric Pollution and Health Impact of Haze. The nature and severity of the smoke emission, the direction and velocity of its dispersion, its persistence and duration, i.e., atmospheric residence-lifetime, the height at which it resides, its impacts on the economy and society, and smoke attenuation, etc., are influenced by various factors and form the specifics of haze monitoring. The fuel type and the interaction of haze with other atmospheric pollutants influence the nature and chemistry of the smoke, its particulate conversion ratio and carbon monoxide and carbon dioxide ratio in haze, as well as its impact on visibility. These in turn define the Pollutant Standard Index (PSI) and/or Air Pollution Index (API). Wind movement and velocity and other climatic factors decide the residence time of haze over the atmosphere. A considerable amount of research is still needed to fully understand the haze formation and dispersal phenomenon.

The negative impacts of haze on human health are closely related to the density and chemical composition of the emissions that escape from large-scale fires. The main purpose of atmospheric monitoring is to provide timely haze warnings based on the PSI and API. A warning system for haze relies on the ability to predict deterioration visible in any place over a long period, as meteorological forecasting skills permit. The most basic forecasting tool is a box model that accepts the generated smoke into a fixed volume air.

Ex-post monitoring. The purpose of ex-post monitoring is to correctly measure the various impacts of fires and haze, to plan remedial measures.

Information Needs. The types of monitoring data and measurements involved in fires and haze are varied in nature, e.g., land-based measurements, ship-platform-borne measurements, aircraft-borne measurements, satellite and spacecraft-borne measurements, and a wide range of meteorological information.

To obtain high accuracy, data need to be properly calibrated and validated. The analysis of data will require the availability of a geographic information system database, which must comprise regional vegetation distribution map, fuel map, fire risk map, and land use map with information on fire agents, causes, etc. For combined fire-smoke analysis, this kind of database can then be linked to atmospheric chemical analyses.

ASMC in Singapore is the prime regional institution for monitoring forest fires and associated haze and gathering related information, supported by national meteorological services. Together they carry out (i) traditional activities related to meteorological monitoring and forecasting; (ii) monitoring and surveillance functions, including hot spot identification through satellite imageries, haze trajectory modeling, compiling monthly and seasonal climate prediction information, and activities related to air quality monitoring; and (iii) effective and prompt dissemination of information to environmental and other agencies engaged in fire and haze response and management, and to the public through the Internet and news releases.

Institutions. Under the ORHAP, there is no program on institutions. However, strengthening of institutions is a crucial requirement, impacting on other programs. The aspects and subjects falling under institutions are (i) organizational arrangements, (ii) regulatory and legal instruments, (iii) capacity building, (iv) donor collaboration and partnership arrangements, (v) a system for continuous planning, and (vi) information management.

Organizational System. The ORHAP is a niche in the organizational structure of ASEAN and benefits from the existing infrastructure and arrangements. However, strengthening will be needed in areas of particular relevance to the ORHAP, e.g., information management.

Within the ASEAN system, HTTF has the primary responsibility to manage and monitor the ORHAP. HTTF shares this responsibility with a number of regional and national institutions, i.e., vertically and laterally. The following is a list of responsible institutions:

- ASEAN Ministerial Meeting on Environment;
- ASEAN Ministerial Meeting on Haze;
- ASEAN Senior Officials on Environment;
- HTTF: Indonesia (Mitigation), Malaysia (Prevention), and Singapore (Monitoring);
- Working Group on SRFA-Borneo;
- Working Group on SRFA-Sumatra;
- ASEAN Secretariat-RHAP Coordination and Support Unit, supported by the Environment Unit, the Agriculture and Forestry Unit, Information and Library Unit, Computer Unit, and Culture and Information Unit;
- ASMC, Singapore;
- dialogue partners and collaborative partnerships; and
- NGOs and the private sector.

With such a long list, the need for coordination is evident. The role of the RHAP Coordination and Support Unit (CSU) within ASEAN is crucial. CSU needs considerable strengthening of resources, facilities, and expertise.

Regulatory and legal instruments. Policy and legal instruments are interrelated. The present policy approach concerning response to wildfires and land-use fires is often an ad hoc reaction to a situation that has already developed, rather than proactive mitigation before the emergency arises. Frequently, policy development does not consider the underlying causes of fire incidence and spread, which may lie outside the forest sector, such as rural poverty and deprivation or the effects of other public policies related to land use and incentives. Sometimes forest fire incidence and spread may be caused by ill-conceived forest management, in particular, total fire exclusion policies that have led to fuel accumulation and catastrophic fire outbreaks.

Policy objectives and measures relating to forest fire management need to be clearly articulated and be in tune with the nation's environmental and socioeconomic policies. Forest fire laws and regulations should be developed for the enabling policy objectives to be translated realistically into action and linked to overall environmental and forest laws. There should also be mechanisms with adequate capability and powers to deal with environmental crimes relating to fire.

In short, public policy on fire should be a dynamic political manifestation of the people's concern for their environment, health, and social welfare, and trust in the system of resource governance. Their trust should not be betrayed.

A viable and efficient legal system is important for translating policies into action. Legal instruments help to achieve policy objectives and to implement policy measures. The legal instruments covering the laws, rules, regulations, agreements, and covenants empower an institution to take appropriate action for achieving its mission. Laws contain enabling provisions to establish adequate regulatory measures to ensure achievement of policy objectives. They define the power of the State and the nature and scope of its sectoral institutions.

Legal instruments at the national level as a means of contributing to the achievement of policy objectives affect governmental agencies and the public. Government agencies stipulate the responsibilities and actions that the agency and its personnel are to carry out, and explicitly or implicitly, the limits of its authority.

Smooth implementation of the ORHAP at the regional, subregional, and national levels through cooperative, collaborative and joint activities, and related institutional arrangements calls for a number of interagency and international agreements for legally formalizing such arrangements within the ambit of a mother agreement and/ or an operational protocol. An initiative to establish an ASEAN Agreement on Atmospheric Haze Pollution in the form of a mother agreement is in progress and expected to become operational by 2001.

Capacity Building. Capacity building needs to be undertaken on a continued basis to avoid redundancy. Two aspects that need to be underlined in this connection are research and development, and education and training. Currently, there are several project components being implemented to improve the capability of AMCs in fire and haze management.

Donor Collaboration and Partnerships. Donor support and resources have made vital contributions to address the impacts of repeated forest fires and haze. The donors provided a substantial amount of funds for short-term suppression activities. While this has no doubt been appreciated by AMCs, the sustained funding of short-term fire suppression over an indefinite period is neither feasible nor would it be an efficient use of scarce donor or affected-country resources.

The challenge now is to use the intervening period between the end of the last *El Niño* and the onset of the next to put into place an institutional framework that will prepare the region for subsequent periods of vulnerability to forest fires and haze. This preparation should be such that ASEAN will never again have to resort to a crisis management style response during periods of heightened risk, as it did during 1997-1998. Accomplishing this will require donor funds to be used as efficiently as possible.

While assistance projects play vital roles, it is crucial to ensure that they are fully owned by the AMCs and integrated into the ORHAP, so that activities can run on effectively even after the external assistance is terminated. The role of the donors in addressing the fire-and-haze issue will also have to be redefined. Fire-and-haze-related donor activities will have to be integrated through explicit partnerships, rather than each of the donors simply becoming aware of other donors' involvement. A start has been made in this direction by integrating all donor activities directly into the ORHAP-DIP. When used as intended, the DIP places the onus of developing an integrated operational plan for confronting the fire-and-haze issue directly on the AMCs and ASEAN itself.

System of Continuous Planning. Planning is an institutional responsibility. Preparation of a plan involves several institutional players and inputs from experts and stakeholders. Conceptually, the ORHAP has all the important characteristics of a formal plan, specifically of an action plan. The nature and emphasis of certain levels of actions may vary when compared to a sector plan or a development plan. However, the ORHAP can and does function within the confines of a broader planning framework. The system of continuous planning incorporates updating of the six-year rolling plan and the DIP, monitoring and implementation of the ORHAP, and establishment and operation of an ASEAN Haze Fund.

ASEAN Haze Fund. A study aiming to determine the feasibility, purpose, concept, and alternative financing vehicles for the establishment of an ASEAN Haze Fund was carried out under the auspices of the RETA Project. It also identified various management and institutional arrangements, including operational guidelines for the fund. The study concluded that the creation of the ASEAN Haze Fund is not only feasible but urgent to finance ORHAP-related activities, particularly fire suppression and mitigation operations.

This can be achieved through a cohesive and integrated framework, drawing on the resources of AMCs, including other sources of funding. Action to establish the fund is pending.

Information Management. The importance of information on fire and haze management cannot be overstressed. While the communication system has achieved a high level of sophistication in various spheres of life, there are gaps in the system being used in fire and haze management in Southeast Asia. At site or near fires in comparatively underdeveloped areas, there is often no access to new communication systems.

The following are some of the important problems relating to fire information management identified during the 1997-1998 fires and haze in Southeast Asia:

- data are spread out around various institutions that are often reluctant to share them. If and where available, data are not consistent or in compatible format, and are of low quality and expensive;
- data cannot be communicated in time when needed because telecommunication facilities are not adequate;

- reliable human resources to gather and process data are limited. Data on the 1997-1998 fires were mostly monitored by three foreign-funded satellite-monitoring projects operated by foreign experts;
- data processing was not adequate to produce information for supporting fire management; and
- there is lack of a proper communication plan.

A study carried out by the RETA Project identified four broad categories of information management functions: (i) policy, planning, and program development; (ii) regulatory and technical services; (iii) administrative services and support; and (iv) internal information management, which together formed the ORHAP information systems architecture. The purpose was to summarize the information packages and database to suit the needs of fire and haze management. These are now being put into practice.

Regional Information Center and Clearinghouse. Based on the study, a regional information center and clearinghouse was established at the ASEAN Secretariat. It includes: real-time satellite imagery; a continuously-updated inventory of relevant donor-assisted initiatives; information on past, present, and future meetings, workshops, seminars, and training programs related to transboundary haze; and numerous other features. As the most efficient means of disseminating this information, a public-access web site available over the Internet (http://www.haze-online.or.id) on fires and transboundary haze was established in the region. The Coordination and Support Unit (CSU) is now responsible for the information center and clearinghouse.

To ease the flow of information connected with the implementation of the ORHAP among members of the HTTF, AMMH, and international agencies, a restricted access, i.e., password-required, intranet was established in parallel with the public access Internet web site. This is being used to allow continuous updating of the various DIPs required for ORHAP implementation.

Training programs in the operation and maintenance of the web site were formulated and conducted by the RETA Project. Trainees included ASEAN Secretariat staff who would maintain the web site's content, as well as staff from the Secretariat's Computer Unit, who would be responsible for integrating the web site into the ASEAN Secretariat's overall network of computer users. Separate training programs were conducted for staff supporting the work of HTTF members, to ensure that they would have continuous access to the information posted on the ORHAP intranet.

Looking Ahead

Endorsement of the RHAP document was a watershed in ASEAN's approach to managing the region's transboundary haze pollution problem. While several activities have already been initiated during the last two years under the operationalized RHAP, it still needs to be consolidated as a sustainable system.

Based on past lessons and studies about the future outlook of fire factors and likelihood and fire and haze, there is a pressing need for strengthening the ASEAN regional collaboration in various areas and aspects related to fire and haze management. These include joint activities, continuation and completion of ongoing activities, consultation and undertaking of new activities, fine tuning of fire-related policies, common standards and approaches, a legal system to facilitate regional cooperation, instruments for transboundary haze pollution control, institutionalization of forest fires and haze management, providing a perspective framework for the ORHAP, and elevating institutional strengthening to the status of a program.

Joint Activities. Joint activities of different nature, i.e., collective, cooperative, collaborative, and coordinated, suitable for the different contexts are important means of strengthening the regional approach. Policy studies, research and development, specialized training, remote sensing and satellite-based monitoring, and SRFAs are some of the activities where cooperation has been initiated. This cooperation needs to be further strengthened.

As and when conditions becomes more conducive, and if economy and efficiency warrant it, more and more activities related to fire management can be brought under the regional preview.

Continuation, and Completion of Ongoing Activities. Several activities have been initiated by the ORHAP under the auspices of the RETA Project. Some activities have been started and are ongoing, some are in a nascent stage, and others are still in the form of a plan awaiting approval for funding. Some activities are of considerable magnitude, some are complex in nature, some are short term, and others are of a medium-term nature.

An important task ahead is to carry these activities forward, enhance their functioning, or complete them as necessary to realize the goals. Some of the activities to be seen through are: (i) Completing the network of FSMPs, linking village units all the way up to the regional (SRFAs) level; (ii) increasing and improving the monitoring capacity of ASMC, and establishing an effective monitoring system network; (iii) completing the work on policy changes involving introduction of market-based instruments, system of responsible land clearance bonds, mechanical land clearing, and model codes of practice; (iv) providing training programs on firefighting, fire management and monitoring; and (v) establishing the Regional Fire Research and Training Center for Land and Forest Fire Management.

Consultation, Program Modification, and New Activities. A means of strengthening regional collaboration is through regular and periodical consultation among the AMCs to review the implementation of the ORHAP and assess the need for program modification, including new activities. Some ideas have already come up. These include publication of the ASEAN *Forest Fire Bulletin*, establishment of Pan-ASEAN Fire Centers; incorporation of public health-related activities in the ORHAP; and promotion of dedicated satellites for fire monitoring.

Fine-Tuning Policies. There is no separate forest fire policy in the AMCs. Fire-related policies are included as clauses or provisions in other related policies, e.g., forest policy, environmental policy, land development policy, etc. Separate regulations corresponding to these policy clauses are often issued. These lead to inconsistencies and even conflicts as far as forest fire and haze-related actions are concerned. There is a need for fine-tuning of fire-related policy provisions by removing inconsistencies and providing appropriate focus. *Better still, a separate policy statement on forest fires and haze can be formulated following the accepted procedure involving policy formation, articulation, and formulation.*

Catalyzing policy changes relating to the use of fires that cause atmospheric pollution is not easy. This is a medium-term task that is being undertaken by some countries with bilateral support from international agencies.

An ASEAN regional framework policy on forest fire and associated haze can serve as a model for AMCs to formulate or modify their own policies to suit their needs.

Common Standards and Approaches. For the joint efforts as envisaged in the ORHAP to succeed, it is necessary to adopt common standards and common approaches. The need for harmonization of haze pollution indexes, standardization of the fire danger rating system and hot spot algorithms, common curriculum for fire management training, standard terms and definitions, and common and harmonized system of weights and measures exemplify the importance of common standards and approaches.

Legal System for Regional Cooperation. The different levels in the legal system of the ORHAP will roughly be (i) regional level convention or a mother agreement; (ii) specific agreements such as on transboundary haze pollution; (iii) agreements related to situation and transaction, such as an agreement for sharing meteorological information; and (iv) standard operating procedures for actions falling within the purview of specific agreements, i.e., standard operating procedures for cross-border transfer of firefighting equipment.

For international agreements to be drawn up for various aspects of ORHAP implementation, an enabling legal instrument is necessary. Sustained implementation of the ORHAP would be facilitated significantly by a mother agreement, or a comparable legal instrument that embodies various agreements at the bilateral, subregional, and regional levels. The ongoing initiative for an ASEAN Agreement on Transboundary Haze Pollution is a priority that needs to be seriously pursued.

Institutionalizing Forest Fire and Haze Management. Sustainability of human-made systems such as forest fire and haze management depends on how effectively it has been institutionalized with appropriate mission, structure, and controls for continued and efficient functioning. It is necessary to ensure that the institutional framework is sound and capable of systematic enhancement.

A Perspective Framework for the ORHAP. The emphasis of the ORHAP is on implementation and action. As a rolling six-year plan, its horizon is short. While this has merits from the short-term operational point of view, its lack of a long-term perspective has some serious disadvantages, particularly affecting the consistency of approach and direction. In the absence of a long-term perspective within which the ORHAP could be designed across a rolling time frame, there are no long-term scenarios or reference points to guide annual forward planning. This can lead to planners' bias in the add-on plans, potentially leading to unsteady or even a lack of progress.

On the other hand, a long-term perspective plan, of which the ORHAP will be a part, has the advantage that it can better rationalize the program structure and balance, to achieve the goals in the shortest possible time. As the perspective plan by definition will be closely linked with other related sectors, it also helps to obtain a holistic understanding of the ecological and human aspects of forest fires and haze.

This is an aspect to be considered along the way ahead and acted upon.

Program Status for Institutional Strengthening. In spite of the ORHAP principle that the fire and haze problem of ASEAN region cannot be fixed, but should be managed, there exists the potential danger that it may still concentrate mostly on technical fixes. It is to be noted, however, that the most important impediment in fire and haze management has been the weaknesses and rigidities of institutions and institutional instruments. The three programs of the ORHAP (prevention, mitigation, and monitoring) are technical programs; it may be worthwhile to incorporate institutions or institutional strengthening as another program.

Conclusions

The ORHAP has been designed as a people-oriented, public-interest-propelled system, with a mission to defend the human environment and particularly to prevent transboundary haze. Through its mission to manage forest fires and associated haze, the ORHAP can and should serve as a stabilizing force to support land- and forest-based development in the region. The laudable commitment of ASEAN in this regard needs to be kept undiminished. Complacency should avoided, as it would blunt this commitment.

The Premise

"The earth we abuse and living things we kill, in the end, take their revenge; for in exploiting their presence, we are diminishing our future."—Marya Mannes

"The shining water that moves in the streams and rivers is not just water, but the blood of our ancestors . . . The rivers are our brothers, they quench our thirst. The air is precious to the red man, for all things share the same breath—the beast, the tree, the man, they all share the same breath . . . The earth does not belong to man: man belongs to the earth . . . All things are connected like the blood which unites one family . . . Whatever befalls the earth, befalls the sons of the earth. Man did not weave the web of life; he is merely a strand in it. Whatever he does to the web, he does to himself."—Native American Chief, Seattle

CHAPTER 1

Understanding Forest Fires—The Global Fire Scene

[This chapter discusses the increasing incidence and intensity of forest fires and associated haze in recent years, while underlining the uses of fires as an ecological agent and tool in land and forest management. The major causes of forest fires are analyzed, and the development of fire science and technology as a means of addressing devastating fires is traced. A brief account of international action in the field of forest fires and haze is also provided.]

The Burning Issue

The Report on Global Environmental Outlook 2000 prepared by the United Nations Environment Programme (UNEP) paints a devastating picture of the earth's health at the dawn of the new millennium. The planet is undergoing an unsustainable course of development, fueled by a relentless decline in the environment and degradation of natural resources.

Contributing to this decline are the uncontrolled and wildfires rampaging through lands and forests, affecting the environmental quality and ecological resilience of our habitat.

Forest fires extending to the roadsides, Indonesia, 1997

Photo: Anonymous

Occurring in agricultural land, forests, and rural areas, spreading from one area to another, burning furiously, and causing heavy and suffocating haze, the fires that ravaged the Association of Southeast Asian Nations (ASEAN) region in 1997-1998 reached disastrous proportions. The environmental, economic, and social dimensions and impact of the catastrophic fires, and the associated transboundary atmospheric haze pollution, were profound. The haze caused by the conflagration in the ASEAN region and elsewhere was directly linked to important issues of land use and abuse, toxic contamination, biodiversity conservation, greenhouse gas emissions, and particularly to the importance of fire management within an overall regime of land resource management.

Experience indicates that the underlying causes of fires cannot be fully removed and there is no easy remedy. Hence, abatement through effective and integrated fire management assumes great relevance and urgency.

Global Fire Occurrences

The annual rate of deforestation in developing countries during the 1980s was 16.3 million hectares (ha), while the corresponding figure for the developing countries of the Asian and Pacific region was 4.3 million ha. During the period 1990-1995, there was not much change in the rate of deforestation, standing at 13.7 million ha for all developing countries, and 4.2 million ha for forests of the Asian and Pacific region (FAO 1997). While several causes have been attributed to the alarming rate of deforestation, in the majority of cases, fire has played a decisive role (Mol et al. 1997).

Every year, millions of hectares of the world's forests are being consumed by fires, big and small, resulting in billions of dollars in suppression costs and causing tremendous damage in lost timber, falls in real estate and recreational values, property losses, and deaths. Wildfire is influencing many aspects of our life: the flow of commodities on which we depend, the health and safety of the communities in which we live, and the health and resilience of wildland ecosystems.

There are many forests seldom affected by fire, while others regenerate easily after burning. Some forests are subjected to high fire frequencies and heavy destructive impact. It is difficult to estimate the number and extent of forest fires and related annual losses. Comprehensive reports on losses are not available and forest fire statistics are often deficient (Goldammer 1997e).

Prehistory of Fires

Wildfires have been present on the earth since the development of terrestrial vegetation and the evolution of the atmosphere. Lightning, sparks generated by swaying bamboos, and volcanoes have been some of nature's ways of igniting forests and keeping the plant environment dynamic. As a perfect relationship existed between fire and the ecosystem (Soares 1991), such natural wildfires occurred at long intervals.

Taking a cue from nature, early humans used fire as a tool to alter their surroundings and later to prepare land for cultivation. There is paleontological evidence to show that fires occurred in the prehistoric past. The mythology of many countries features accounts of fires dating back to several thousands of years.

The climate in the tropical Amazonian region is too moist to allow a forest fire to burn as long as the forests are in an undisturbed state. There is, however, evidence that in the remote past, forest fires did occur in the region. For example, Saldarrioga and West (1986) determined that the ages of charcoal fragments collected from the Venezuelan part of the Amazon ranged from 250 to 6,260 years old. Those fires were most likely associated with extremely dry periods or human disturbances (Reis 1996).

Recent History of Fires

Since the 1960s, several fires have attracted world attention. The Parana fire in Brazil in 1963 burned 2 million ha, destroyed more than 5,000 houses, and claimed 110 lives (Reis 1996). With this started the new history of wildfires in Brazil, and a permanent worry, mainly with regard to the damage that fire can cause to forest plantations. The effect of fire on vegetation became an issue in 1988 following devastation to some parts of the Amazon forests. According to the World Wide Fund for Nature (WWF), large-scale logging and forest fires have contributed to the wiping out of some 12-15 percent of the Amazon rain forest. Satellite imagery from the Advanced Very High Resolution Radiometer (AVHRR) satellite, interpreted by the Brazilian National Institute for Space Studies, indicated that 20.5 million ha of Brazil's Legal Amazon (which covers an area of 500 million ha) was burned in 1987, of which about 8 million ha was considered to be

While several causes are attributed to the alarming rate of deforestation, in the majority of cases, fire has played a decisive role

deforestation in the dense forest area (Seltzer et al. 1988). In early 1998, the savannahs in the state of Roraima were left parched by the worst drought in history, resulting in big blazes, which burned some 3.2 million–3.5 million ha. Of this land, about 200,000 ha were good forests and the rest were already deforested areas or secondary forests (Anon 1997a, Reis 1996).

Each year, fires in the Brazilian Amazon burn an area larger than Rio de Janeiro state. Ranchers and subsistence farmers ignite their lands in an attempt to convert forests into fields and to reclaim pastures from invading weeds. Subsistence farmers have migrated from all parts of Brazil to the fringes of the rain forest, lured by government promises of free land and a better life. But despite the lushness of the nearby forest, the soil is too poor to support intensive agriculture. They arrive armed with hope and chainsaws, clearing and burning land to farm the poor soil.

The fires set by ranchers and subsistence farmers often get out of hand, inadvertently burning forests, pastures, and plantations (WCFSD 1999).

The results of a seven-year study conducted by the Woods Hole Research Center in Massachusetts, US, suggest that the Amazon rain forest is experiencing an acute drying, leading to increased susceptibility to fire. Recent tests involving digging for water at many sites found dry ground, while similar tests seven years earlier revealed water close below the surface (Reis 1996, WCFSD 1999).

Statistics in the People's Republic of China (PRC) reveal that between 1950 and 1990, 4,137 people were killed in forest fires (Goldammer 1994a). In the same period, information from satellites reveals that about 14.5 million ha of forest were affected by fires in the neighboring Soviet Union, predominantly burning in the Siberian boreal forests, which have a composition similar to the northeastern PRC (Cahoon et al. 1994).

The Kalimantan fire in Indonesia in 1982 burned about 5 million ha and caused losses amounting to $9.1 billion. Fires have swept through the forests of Kalimantan and Sumatra (also elsewhere) in Indonesia several times during the last two decades, engulfing millions of hectares and causing losses estimated at billions of dollars (Goldammer et al. 1996).

In 1983, the Ash Wednesday fire in Australia caused 76 deaths, killed 300,000 sheep and cattle, and burned more than 2,500 homes. The Great Black Dragon Fire of the northern PRC in 1987 burned around 1.3 million ha, destroyed more than 10,000 houses, and resulted in a death toll of about 200. The Yellowstone fire in the United States in 1988 almost completely burned out one of the world's most famous parks, costing about $160 million to suppress, and causing an estimated loss of $60 million in tourist revenues between 1988 and 1990 (Polzin et al. 1993). In the longer term, however, the increased biodiversity created by the fires in Yellowstone National Park may well yield benefits that outweigh these losses.

In 1982-1983, Cote d'lvoire in West Africa was swept by wildfires over a total area of about 12 million ha. The burning of some 40,000 ha of coffee plantations, 60,000 ha of cocoa plantations, and some 10,000 ha of other cultivated plantations had detrimental impacts on the local economy and left more than 100 people dead during this devastating fire period (Goldammer 1998b).

In the last four years, unusual weather conditions (and global weather changes) have led to fires in several parts of the world. Some of the conflagrations during 1996-1998 have been particularly damaging, as fires swept across the fragile rain forests of South America

During the last four years, unusual weather conditions (and global weather changes) have led to fires in several parts of the world

and two waves of forest fires gripped Indonesia, causing a national disaster.

Fires in Mexico and Central America have burned a reported 1.5 million ha. These have generated large quantities of smoke, which have blanketed the region and spread into the United States as far north as Chicago. From January to June 1998, about 13,000 fires burned in Mexico alone. Figures released by Mexican authorities in May 1998 indicated that a reduction of industrial production in Mexico City, which was imposed in order to mitigate the additional smog caused by forest fires, involved daily losses of $8 million.

Between December 1997 and April 1988, more than 13,000 fires burned in Nicaragua, the most in any Central American country, destroying vegetation on more than 800,000 ha of land. The Nicaraguan Ministry of Environment and Natural Resources recorded more than 11,000 fires in the month of April 1998 alone.

In July 1998, devastating forest fires affected more than 100,000 ha in eastern Russia. Coniferous forests burned in more than 150 locations around Vladivostok, Sakhalin, and Kamchatka peninsula. In Russia's Pacific island of Sakhalin alone, more than 25,000 ha of forest were consumed by fire during September 1998. The same year, forest fires in Florida, in the United States, burned an area of some 100,000 ha (Goldammer 1998b).

Fires burned the forests and pastures of Mongolia consecutively in each of the years between 1996 and 1998. The 1996 fires affected an area of 10.2 million ha, including 2.4 million ha of forests, in which 22 million cubic meters (m^3) of forest growing stock were lost. The 1997 fires affected more than 12.4 million ha, of which forests accounted for 2.7 million ha. This fire killed some 600,000 livestock while damage to the Mongolian economy was estimated at $1.9 billion (Chandrasekharan 1998a).

Fires burned the forests and pastures of Mongolia consecutively in each of the years between 1996 and 1998

Fire Data

Reliable data on the occurrence of wildland fires, areas burned, and losses are available for only a limited number of nations and regions. Within the northern hemisphere, the most complete data set on forest fires is periodically collected and published for the member states of the Economic Commission for Europe, covering Canada, all western and eastern European countries, countries of the former Soviet Union, and the US. The last data set covers the period 1994-1996 (ECE/FAO 1997). In the European Union (EU), a Community Information System on Forest Fires has been created on the basis of information collected on every fire in national databases. The collection of data on forest fires (the common core) has become systematic with the adoption of a Commission Regulation in 1994.

The Community Information System on Forest Fires covers 319 provinces (departments, states) of France, Germany, Greece, Italy, Portugal, and Spain (European Commission 1996, Lemasson 1997). It contains information on 460,000 fires recorded between 1 January and 31 December 1995, involving a total of 6 million ha.

A global data set has been developed on the basis of active fires detected by the National Oceanic and Atmospheric Administration (NOAA) AVHRR sensor—the "Global Fire Product" of the International Geosphere-Biosphere Program under its subcomponent of Global Vegetation Fire Information (GVFI) System.

The fire data set includes all free-burning vegetation fires (wildfires in forests, savannahs, and other vegetation; prescribed burning), use of fire in agricultural systems (e.g., burning of

Every region has its own peculiarities and the role of fire varies not only between regions, but also within each region from habitat to habitat

agricultural residues, prescribed burning) and burning of plant biomass in households (fuelwood, charcoal, etc.).

Fire Type Classification

Forest fire type classification is important in designing and implementing appropriate control measures. Forest fires are variously classified, based on:

- source of ignition: natural and human-made fires, which may result from carelessness and accident, or may be incendiary in nature (often using fire as a weapon instead of as a tool);
- size of area affected: large (e.g., more than 50,000 ha), medium, and small fires (irrespective of the nature of damage);
- intensity of burn and damage: very heavy, heavy, medium, and light fires (depending on fuel load and other factors [e.g., duration]); and
- nature of burn: underground fire (e.g., coal seams), ground fire (that consumes the organic materials beneath the surface litter), surface fire (that burns surface litter and other loose debris of the forest floor), creeping fire (that spreads overground), and crown fire (consuming the upper branches and foliage). Crown fires often burn the ground level vegetation and canopy of the forest, and are the most damaging.

Depending on the circumstances, weather, fuel load, undergrowth, etc., one form of fire may change into another or into a combination of different types. The impact of fire depends on the type.

Fire Frequency and Intensity

Fire frequency and intensity are both a cause and an effect of ecosystem characteristics and are fundamental variables in the negative or beneficial effects of fire. However, every region has its own peculiarities and the role of fire varies not only between regions, but also within each region from habitat to habitat. A great deal has been learned from fire research and management in temperate and subtropical ecosystems. However, fire management practices found to be successful in these regions should not be applied automatically to the tropics.

Fire Frequency

Fire frequency, measured as the return interval between fires, may be as short as one year or may extend into centuries. Fire frequency and intensity are not fully independent variables. Areas with short return interval fires tend to have less intense fires than areas with long return interval fires. Moreover, many ecosystems are subjected to low-intensity, short return interval fires as well as less frequent, high intensity fires. The relationship between frequency and intensity is complicated by a variety of factors such as vegetation structure, productivity, weather, and topography. Grasslands, for example, can support high intensity fires that burn annually.

A distinction is often made between fire frequency and fire incidence. Fire frequency is used to refer to the fire return interval at a particular location, whereas fire incidence is used to refer to the interval between fires that burn within a specified land unit, but not necessarily at the same point.

Fire Intensity

It is difficult to provide a conventional definition for fire intensity. If the focus is on energetics or fire behavior, then fire intensity is best defined in terms of energy released per unit time per unit of fire front. If it is on carbon or nutrient cycling, or fuel reduction, then fire intensity is the energy or biomass consumed per unit area. These measures may or may not be of use to measure the impact of fires on ecosystem biota. For example, low intensity surface fires in ecosystems composed of vulnerable species result in substantial changes. In contrast, high intensity crown fires in savannahs or pine forests can simply stimulate reproduction of the same species, with little change in the overall composition of the ecosystem.

Influencing Factors

A variety of environmental factors regulate fire frequency and intensity. Climate influences fire variations on a geographic scale. The frequency of lightning discharges and associated rainfall are the most important variables influencing ignition in some ecosystems. However, in others, humans have been able to and still do control the frequency of fire starts. In general, fire frequency increases inversely with moisture availability. On the other hand, in very dry areas, slow rates of biomass accumulation can result in longer fire return intervals.

Topographic diversity and vegetation patterns regulate fire frequencies in any given area. Vegetation also influences intensity. In many temperate ecosystems fuels tend to accumulate as vegetation ages. Such an accumulation is often associated with the production of hard and dense leaves and waste wood. Further, the quality and distribution of these fuels also change. In any case, such changes act as feedback mechanisms about the likelihood of ignitions.

Changes in vertical and horizontal fuel distribution associated with ecosystem development also affect fire frequency and intensity. Given sufficient time between fires, understory trees and debris form a vertical pathway, or “ladder,” of fuels from the forest floor to the canopy along which fire may be carried into the crowns. Repeated burning tends to reduce fire intensity, though the long-term ecological consequences of such burning may vary.

Variations in fire behavior and frequency greatly influence post-fire vegetation development. In ecosystems with light to moderate intensity fires, and short return intervals, post-fire species composition may be quite similar to the pre-fire composition. In ecosystems with longer and perhaps less predictable return intervals, post-fire ecosystem response typically follows a classical species replacement series. The similarity between pre- and post-fire composition is also determined in some ecosystems by fire intensity.

Humans’ historic role in changing fire frequency and intensity is variable. Human influence has generally resulted in an increase in fire frequency, but fire intensity increased or decreased in different vegetation types. In tropical regions, where human association with the vegetation has been more prolonged, this alteration of ecosystems from previously existing conditions may have been more dramatic. The growth of population and economic development have increased the damage caused by forest fires, and the fire cycle around the world has quickened—in some cases from more than 100 years to only three to four years, or even less. Also, in the West’s coniferous forests and North’s forests, fire suppression has resulted in substantial changes in fuel conditions. Although modern humans further increased the number of fire starts, the area burned by fires has declined in many vegetation types. Consequently, fuels have accumulated and fire intensities have risen. In the tropics, intentional burning for forest cultivation and agriculture has increased fire incidence (Goldammer and Odintsov 1998).

Human influence has generally resulted in an increase in fire frequency, but fire intensity increased or decreased in different vegetation types

Factors Responsible

Analysis of causes is an important step toward designing control measures, management policies, and action. Historical perspectives provide an insight into future needs. There are predisposing factors or inherent conditions, as well as immediate causes that might result in wildfires and influence their frequency and intensity. These are often interrelated.

Predisposing Factors

The predisposing factors are various and may include the following:

- economic (poverty and dependence of rural communities on forests for livelihood);
- demographic (increased population pressure on forests for their goods and services);
- meteorological (weather conditions including high temperature and lower atmospheric humidity);
- crop conditions (amount of canopy opening causing desiccation and water stress, nature and amount of ground vegetation, and fuel load);
- nature and condition of ecosystem (vegetational types, fire resistance level of component species, and locational topography);
- sociocultural (cultural significance of fire to the forest dwelling and rural communities); and
- institutional (lax environmental laws, inadequate enforcement capability, indifference of public administration to environmental matters, lack of dissemination of weather information and fire danger warnings, misuse of funds earmarked for fire protection, and management and policy weaknesses).

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Immediate Causes

The contribution of natural fires to tropical wildland fires today is negligible. Most tropical fires are set or spread accidentally or intentionally by humans, and are related to several causative agents, some of them linked to subsistence livelihood, others to commercial activities (Goldammer 1997a, e). These include:

- deforestation (conversion of forests to other land uses, e.g., as agricultural land and pastures);
- land clearance and land preparation for agricultural crops;
- traditional slash-and-burn agriculture;
- grazing land management (fires set by graziers, mainly in savannahs and open forests with distinct grass strata);
- extraction of nonwood forest products (NWFPs) (using fires to facilitate harvests or improve the yield of plants, fruits, and other forest products, such as honey, resin, and antlers, predominantly in deciduous and semideciduous forests);
- wildland/residential area interface fires (fires from settlements, e.g., from cooking, torches, camp fires, etc.);
- other traditional fire uses (in the wake of religious, ethnic, and folk traditions; tribal warfare);
- socioeconomic and political conflicts over questions of land property and land-use rights, using arson;
- speculative burning to stake land claims; accidental fires (e.g., due to falling of dry leaves and twigs on high tension electricity lines); and
- fires introduced by design (e.g., prescribed fires) going out of control and becoming wildfires.

Another factor to be noted in this regard is the connection between population growth and deforestation. The 1995 world population stood at 5.7 billion, and is expected to grow to about 9.4 billion by 2050, with all the attendant impacts on natural resources.

How to obtain a respite from deforestation and forest fires and haze is a major management challenge.

Fuel Loading

Air, temperature, and fuel are considered the three corners of a fire triangle. It is the volume, type, and condition of fuel that determine the rapidity and intensity of any fire. Moisture content in fuels could minimize the chances of a blaze, as moisture must evaporate to permit the temperature to rise to ignition point. The constant circulation of wind dries up the fuel, boosting chances of an outbreak and helping the blaze to spread.

The vegetation characteristics themselves are a major determinant of fire occurrences. Fuel-loading capacity in terms of plant density and plant lifeform combination (i.e., woody plants of various sizes and herbaceous plants, particularly grasses) determines the fire potential of vegetation. The soil substrate and its microorganism activity contribute to the fuel-loading capacity. If decomposition of the annually produced litter is slow, organic matter builds up at the soil surface. This is a leading cause of forest fires in temperate environments.

Ignition Source

Fire in the tropical rain forests is often related to forest clearing for agriculture, industrial timber plantations, and other land-use changes, of which three broad types can be distinguished.

- Shifting cultivation where land is allowed to return to forest vegetation after a relatively short period of agricultural use. Traditionally, shifting cultivation provided a sustainable base of subsistence for indigenous forest inhabitants and had little impact on forest ecosystem stability. Today, shifting cultivation is practiced by some 500 million people on a land area of 300 million-500 million ha (Goldammer 1993a) and is often unsustainable due to the increase in size of individual plots and shorter fallow periods.
- Temporary complete removal of forest cover in preparation for industrial timber plantations.
- Permanent conversion of forests to grazing or cropland, as well as other nonforestry land uses.

In all cases, clearing and burning initially follow the same pattern; trees are felled at the end of the wet season and the slash is left to dry for some time. The efficiency of the first burning is variable; often not exceeding 10-30 percent of the ground biomass due to the large amount of forest biomass in tree trunks and stumps. The remainder is tackled by a second fire or left to decompose.

The burning of primary or secondary rain forest vegetation for conversion purposes has accelerated in recent years. Such forest-clearing fires often escape and have been shown to often lead to large-scale wildfires in undisturbed rain forests under the right climatic conditions.

While a land fire (e.g., in farmlands) may lead to a forest fire, a distinction is often made between the two in view of the differences in their causes, impacts, control measures, etc. Forest fires and associated haze have damaging impacts, but not designed and controlled burnings.

Some ecologists assert that fire is nothing more than a secondary factor in the destruction of dense and moist rain forests, which will not burn unless interference causes inflammable materials to be present or accumulated. Logging can increase the susceptibility of tropical rain forest to fire, particularly when carried out in

Fire in the tropical rain forests is often related to forest clearing for agriculture, industrial timber plantations, and other land-use changes

Climate is a crucial control factor in fire occurrence and frequency, since it determines not only the vegetation, but also influences soil microorganism activity, and thus litter decomposition

an unnecessarily destructive and wasteful manner or resulting in large gaps in the forest canopy. Such practices can cause the accumulation of flammable biomass, invasion by weed species, and desiccation of soil organic matter—all factors that make forests susceptible to wildfire.

A series of disturbances may also increase the susceptibility of rain forests to fire. For instance, the extended rain forest fires of 1989 in Yucatan (Mexico) that burned some 90,000 ha were the result of a chain of disturbances. In 1987, Hurricane Gilbert damaged and opened the closed forests, leaving behind unusual amounts of downed woody fuels. These fuels were then desiccated by the drought of 1988-1989, and the whole forest area was finally ignited by escaped land-clearing fires. None of these three factors, the cyclonic storm, the drought, or the ignition source, if occurring alone, would have caused a disturbance of such severity (Goldammer 1992a).

Climate—An Aggravating Factor

Climate is a crucial control factor in fire occurrence and frequency, since it determines not only the vegetation, but also influences soil microorganism activity, and thus litter decomposition. In tropical lowland environments, litter decomposition is generally fast, and organic matter accumulation is rarely an important factor. However, climatic seasonality in terms of wetness and dryness is the most important parameter related to fire occurrence. Thus, a climate and vegetation analysis is imperative for an assessment of fire occurrence and frequency. Climatic seasonality does not manifest itself only on a month-to-month basis, but also in year-to-year variation (Mueller-Dombois 1978).

If precipitation falls below 100 millimeters (mm) per month, and periods of two or more weeks without rain occur, the forest vegetation sheds leaves progressively. In addition, the moisture content of the surface fuels is lowered, while the downed woody material and loosely packed leaf-litter layer contribute to the buildup and spread of surface fires.

Aerial fuels such as desiccated climbers and lianas become fire ladders potentially resulting in crown fires or "torching" of single trees.

The occurrence of seasonal dry periods in the tropics increases with distance from the humid equatorial zone, leading to more open, semideciduous, and deciduous forest formations. Such forests are subject to frequent fires (often annual, but sometimes two or three times a year), and fire-tolerant species tend to dominate. The main fire-related characteristics of these formations are seasonally available flammable fuels (grass-herb layer, shed leaves). The most important adaptive traits that characterize the vegetation include thick bark, the ability to heal fire scars, resprouting ability, and seeds that feature fire adaptations.

Weather Variability

Meteorologists, based on available thermometric record, have determined that four of the hottest years in history occurred in the 1990s—1990, 1995, 1997, and 1998. The first five months of 1998 were the planet's hottest on record according to the scientists of the US NOAA. The *El Niño* phenomenon is considered to be the main reason behind the mercury ascent and is frequently blamed for major forest fires. About 93 percent of all droughts in Indonesia have occurred during an *El Niño* (Goldammer and Manan 1996). *El Niño* affects the global weather pattern, resulting in extreme dry conditions, which in turn leave forests parched and open to fires. Thus, while *El Niño* is not a source of fire, it aggravates the danger of fires in places where negligence and management lapses can lead to severe conflagrations. Some point out that *El Niño* has always been in existence, without frequently causing major forest fires in the past. This may be due to the existence of relatively undisturbed forest cover with dense canopies in most tropical ecosystems that prevented drying of the lower vegetative strata, particularly the ground cover.

El Niño *Southern Oscillation and Global Weather*

El Niño is a periodic oceanographic phenomenon in which a strong and extensive warming occurs in the upper ocean in the tropical eastern Pacific, upsetting weather patterns globally. The *El Niño* effect leads to the strengthening of a warm ocean current called the equatorial countercurrent in the mid-Pacific, causing the entire weather mechanism to be disrupted. Rainfall is delayed, crops are adversely affected, and storms occur where they should not. Occurrence of *El Niño* is linked with a change in atmospheric pressure known as the Southern Oscillation, and the overall phenomenon is often called the *El Niño* Southern Oscillation (ENSO). ENSO consists of *El Niño*—a "warm phase" or a large warming in the equatorial Pacific Ocean—and *La Niña*—a "cool phase" in which surface waters of the central Pacific Ocean are colder than normal.

The typical global impact of ENSOs is the anomalous pattern of rainfall and temperature. The surface ocean in the central and eastern equatorial Pacific is normally colder than that in the western equatorial Pacific. In some years, however, the ocean is especially warm. This warming typically occurs around Christmas and lasts for several months. It is caused by a complicated atmospheric-oceanic coupling that is not yet entirely understood. During these warm intervals, fish are less plentiful (it was the fishers along the coasts of Ecuador and Peru that originally termed the phenomenon "*El Niño*" [Spanish for "the Christ child"]) (Goldammer 1997d).

In the eastern equatorial Pacific, the overlying air is heated by the warmer waters below, increasing the buoyancy of the lower atmosphere and fueling convective clouds and heavy rains. But the air over the cooler western equatorial Pacific becomes too dense to rise to produce clouds and rain—in other words, dry conditions result in Australia, Indonesia, and Philippines, while more flood-like conditions are caused in Ecuador and Peru. Over the past 50 years, 12 major *El Niños* have been recorded. The worst of these began in March 1997 and faded away in June 1998. Before this, the *El Niño* of 1982-1983 had been the most severe (See Box 1, and Figures 1 and 2).

According to scientists, the frequency and intensity of *El Niños* are on the increase. In the 19th century, *El Niño* appeared on average every seven-and-a-half years; now it comes at intervals of less than five years. The reasons for this increased frequency are not clear. There is a suggestion that the recent mood swings of *El Niño* have been due to climatic changes and global warming, with greenhouse gases, mainly carbon dioxide, the most dominant factor in the global weather changes (Goldammer 1997f and 1998a).

In contrast to *El Niño*, *La Niña* ("the girl child") is associated with unusually cool ocean temperatures across the central and eastern equatorial Pacific. This generally causes sharp reversals of weather patterns around the globe and occurs roughly half as often as does *El Niño* (only six major *La Niñas* have been recorded in the past 50 years). In *La Niña* years, monsoons are enhanced over Australia and Southeast Asia, but the central equatorial

According to scientists, the frequency and intensity of *El Niños* are on the increase

BOX 1 Walker Circulation

In the 1920s, Sir Gilbert Walker made the seminal connection between barometer readings of air pressure at sea level at stations on the eastern and western sides of the Pacific Ocean. He observed that when pressure rises in the east, it usually falls in the west, and vice versa. This effect, which explains the *El Niño* phenomenon, is referred to as the Walker Circulation. Walker and his team analyzed weather records until they found patterns of rainfall in Latin America that could be associated with changes in ocean water temperatures.

In the warm Indonesian archipelago, extensive burning of vegetation (from shifting cultivation, forest conversion, and other agricultural burnings) takes place. Although the impacts of these fires on atmospheric chemistry have not yet been explored, it is assumed that two major patterns of emission take place based on Walker Circulation. During the "high phase" (normal years) of the Walker Circulation, low pressure is centered over the Indonesian hot spots. Air masses with products from biomass burning (aerosols, trace gases) are carried to the high troposphere and exported globally. During the "low phase," the warm waters from the west are transported to the eastern Pacific, and high pressure builds up over the Indonesian archipelago. A typical situation develops during which emissions from biomass burning are trapped in the lower troposphere.

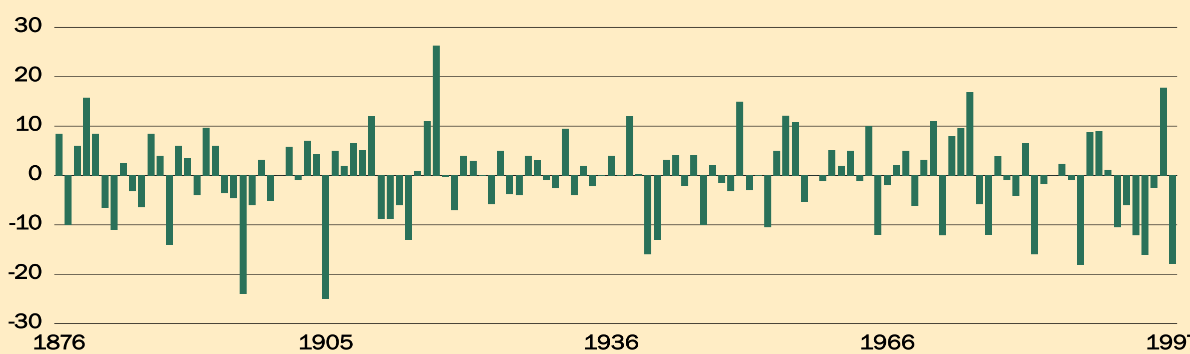
The last few years, with extraordinary fires in Indonesia, have been characterized by the low phase of the Walker Circulation. (Anon 1997a, Goldammer 1998b)

Pacific becomes drier than usual, a reverse of the *El Niño* effects. *La Niña* does not necessarily follow hard on the heels of *El Niño*. However, it has done so three times in the past 15 years. In general, slightly higher than normal rainfall has been recorded during *La Niña*; but in certain years the amount of rainfall can be much higher than in *La Niña* years (Nicholls 1993).

The last *La Niña* started to develop in mid-1998. Unusual climate conditions in 1998 that may be associated with *La Niña* included dry weather in parts of South America; wetter than normal conditions in northern Australia and the Philippines; above-normal rainfall during the southwest monsoon in India; increased hurricane activity in the Caribbean and Central America; dry spells in parts of Argentina and Chile; above-normal rainfall in southern Africa, with the exception of Zimbabwe; and possibly drier than normal conditions in the Horn of

FIGURE 1 Visitations of *El Niño*

There have been 20 ENSOs in the 120 years since 1877. There is now much debate surrounding the idea that the frequency and intensity of ENSOs are increasing, and there is some evidence that this has been the trend in the past 20 years.



The figure shows the *El Niño* Southern Oscillation Index (ENSOI) six monthly average (April–September) for the years 1876–1997.

Source: MOE-UNDP 1998.

Africa. Several governments took steps to prepare for the 1998-1999 *La Niña*, including upgrading drainage systems, limiting development in high-risk areas, and improving flood control.

Impacts of El Niño

In 1982-1983, *El Niño* caused worldwide destruction, particularly severe flooding and extensive damage in Latin America and droughts in parts of Asia. In Australia, forest fires destroyed thousands of houses and took countless lives in the *El Niño* season of 1982. The total damage wreaked by the 1982-1983 *El Niño* phenomenon globally was estimated to be between $8 billion and $13 billion, with about 2,000 lives lost. In 1991-1992, the effects of *El Niño* led to severe drought in Southern Africa, bush fires in Australia, and forest fires in Indonesia . During 1997-1998, *El Niño* spread from the Pacific to vast areas in Australia, Asia, and Africa. It caused severe droughts in Australia, Indonesia, Papua New Guinea, and Philippines; led to famine in southern Africa, and hurricanes in Mexico and the southern United States. This *El Niño* fueled forest fires in Indonesia, Malaysia, and Thailand, as well as in the Amazon.

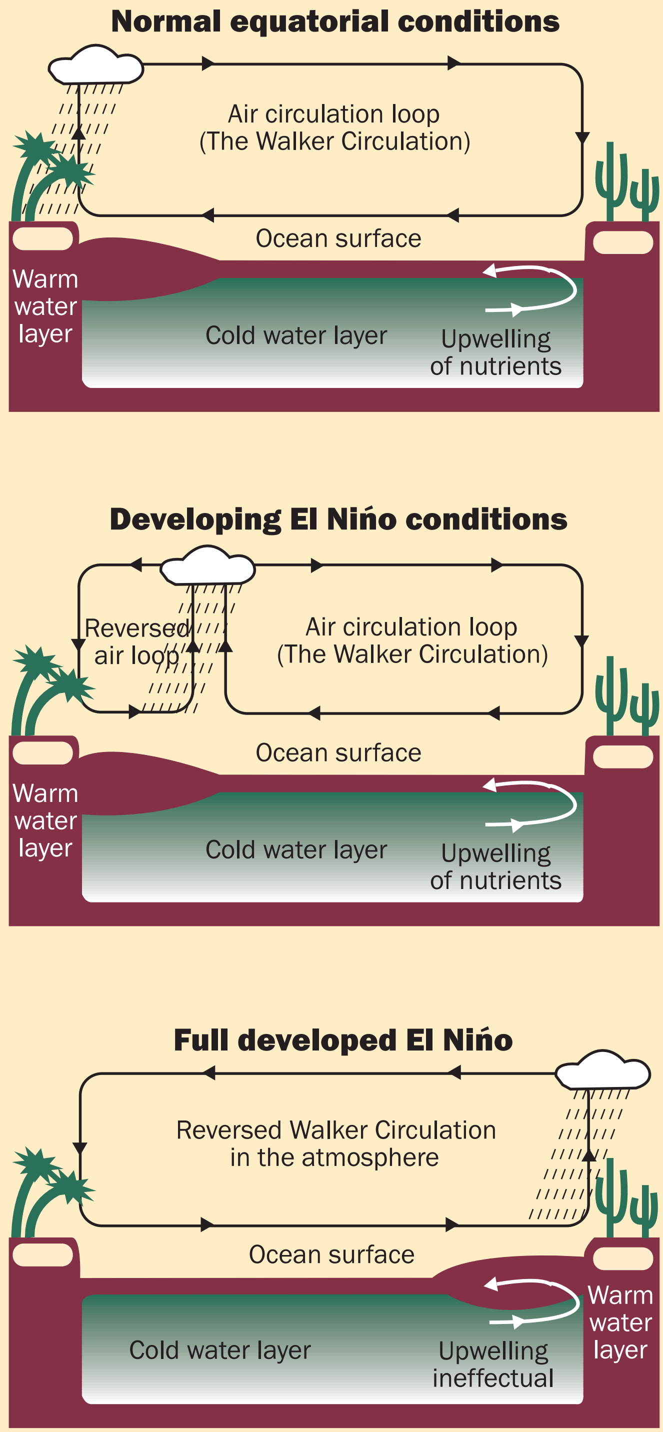
The recent devastation caused by *El Niño* has added a new urgency to a long running scientific mission: the quest to be able to forecast weather precisely, and to understand the causes and effects of unusual climate swings.

The Array of Impacts

The burning of forests and biomass has serious impacts, direct and indirect, often resulting in loss of life, livestock, and capital. The damage caused by fire is often difficult to quantify, especially when nontangible losses are involved. The impact of forest fires has several dimensions—environmental/ecological, social,

FIGURE 2 **The Walker Effect**

Change in the temperature of the sea affects wind patterns, which affect weather globally.



Source: Institute of Ocean Sciences, Canada, *Down to Earth*, December 1997.

Tropical lowland rain forests are essentially nonflammable vegetations, but once invaded by grasslands they become easily degraded by frequent fires

economic, and others, which could be onsite and offsite. The extent of these impacts depends on the frequency and intensity of fires, fuel load, type of forest involved, and climatic factors.

Ecological and Environmental Impacts

The ecological impact of forest fires is manifest in the degradation of the quality of vegetation; expansion of savannah and sterile grasslands; erosion of biodiversity; damage to the health of forest ecosystems; plant mortality; loss of wildlife habitat; air, river, and estuary pollution; and overall ecological retrogression. Some authors point out that as humans ascend the ladder of civilization, their needs grow in arithmetical progression and the corresponding pollution grows in geometrical progression (Muralikrishna 1999). Fires affect the quality and productivity of soil by destroying humus and altering its chemistry, increasing soil temperature, attacking microbial inhabitation, reducing moisture retention capacity of the soil, causing erosion of surface soil and nutrient loss, increasing runoff, lowering the subsoil water table, and causing desertification—ultimately reducing the carrying capacity of the land involved.

Influence on Ecosystems

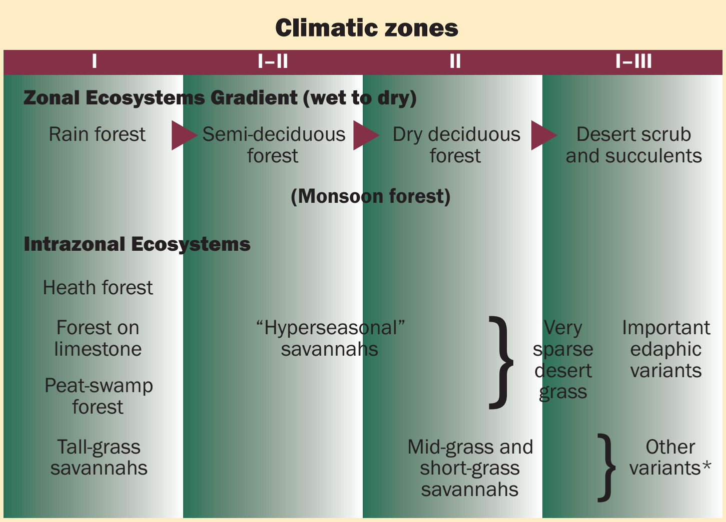
Fire has been, and continues to be, particularly destructive in tropical Africa, while high fire frequency in tropical Australia has resulted in a generally more fire-adapted vegetation. Tropical lowland rain forests are essentially nonflammable vegetations, but once invaded by grasslands they become easily degraded by frequent fires, destroying a good portion of their floristic and ecological potential. Slash fires following logging increase the fire hazard in tropical forests because they promote the establishment of fire-prone grasses. Therefore, fire as a management tool has a different outcome in tropical as compared to temperate forests.

Within the tropics (from latitudes 23° N to 23° S), three types of tropical lowland climate are recognized:[1] the humid tropics (I), the subhumid or semidry tropics (I-II), and the dry tropics (II). The three tropical climate zones are based on mean monthly rainfall and temperature distribution. These three zones correspond roughly to the potential terrain of the three zonal forest types: tropical rain forest (zone I, extending to about 10° N and 10° S of the equator in tropical America, Africa, and Southeast Asia), semideciduous forest (zone I-II, recognized as a broad climatic transition zone in tropical America and Africa, but almost absent in Southeast Asia), and dry deciduous forest (zone II, which is the largest tropical climate type). Zone III represents edaphic (soil-influenced) and other variants.

A generalized spatial gradient of the tropical ecosystems is shown in Figure 3.

Zonal tropical rain forests occur typically on well-drained, deeply weathered lateritic[2] clay soil

FIGURE 3 Generalized Spatial Gradient of Tropical Ecosystems



*Mostly anthropogenic.
Source: Mueller-Dombois 1978.

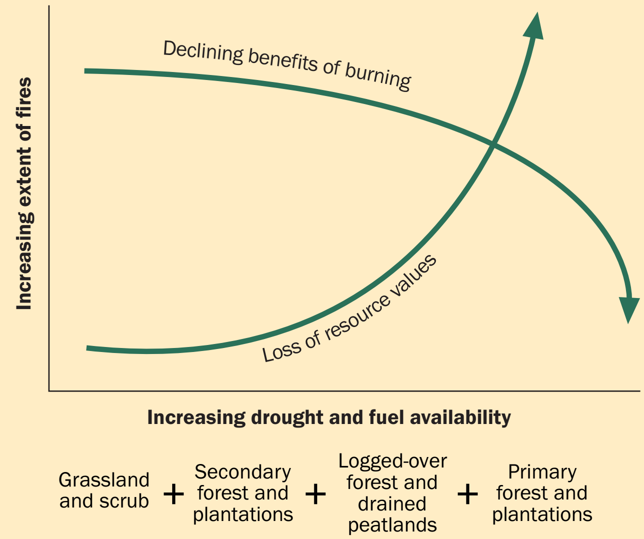
(oxisols and ultisols), which contain little organic matter and nutrients. These soils are highly acidic (generally pH 4.2-5.6) and contain poor oxide clays with low exchange capacities. They commonly undergo irreversible drying when exposed to strong desiccation.

Whitmore (1984) described several other tropical lowland rain forests that occur on quite different soils. These are the tropical heath (Karangas) forests on podzolized[3] sands; the rain forests on limestone, ultrabasic (serpentine) rock, calcareous sand and coral rocks along beaches; and peat-swamp forests. All are significant edaphic variants, which can be treated as intrazonal forest types in the tropical rain forest terrain.

Peat-swamp forests are an important rain forest type in Southeast Asia (Whitmore 1984), as well as in tropical America and Africa (USDA-FS 1981). In spite of their often turflike accumulation of organic matter, natural fires have apparently not been observed in this edaphic variant of the tropical rain forest. Savannahs are the most widespread tropical vegetation type today, with different subtypes due to edaphic variations in the tropical seasonal environments.

It is not proposed to go into the details of various types of vegetation. In all cases, however, it is necessary to have a clear idea about the positive and negative roles of fire. Figure 4 provides an illustrative case.

FIGURE 4 **Conceptual Diagram of Losses and Benefits of Forest Fires in Indonesia**



Source: IAP Working Group, Indonesia, 1999.

Release of Greenhouse Gases

Forest fires contribute to global climate change and warming. Burning of forests also destroys an important sink for atmospheric carbon. Biomass burning is recognized as a significant global source of emissions contributing as much as 10 percent of the gross carbon dioxide and 38 percent of tropospheric ozone (Goldammer and Seibert 1990, Landsberg 1997).

Depending upon the severity of annual burning and the weather, the emission products added to the atmosphere from biomass burning amount to 220-13,500 gigatons (Tg) of carbon dioxide, 120-680 Tg of carbon monoxide, 2-21 Tg of nitrous oxides, and 11-53 Tg of methane gas. The situation, obviously, is not very comforting. According to one estimate, in just a few months the burning that took place in 1997 in Indonesia released as much greenhouse gases as all the cars and power plants in Europe emit in an entire year (Kristof 1997). Scientists have estimated that from 1850 to 1980, between 90 billion and 120 billion metric tons (mt) of carbon dioxide were released into the atmosphere from tropical forest fires.

In comparison, during that same time period, an estimated 165 billion mt of carbon dioxide were added to the atmosphere by industrial nations through the burning of coal, oil, and gas.

In just a few months the burning that took place in 1997 in Indonesia released as much greenhouse gases as all the cars and power plants in Europe emit in an entire year

> Smoke emissions from wildfires affect human health, particularly causing respiratory ailments, and in some cases, disease and death

According to recent estimates, some 1.8 billion-4.7 billion mt of carbon stored in vegetation may be released annually by wildland fires and other biomass burning (Crutzen and Andreae 1990). However, not all of the biomass burned represents a net source of carbon in the atmosphere. The net flux of carbon into the atmosphere is due to deforestation (forest conversion with and without the use of fire) and has been estimated by Houghton (1991) to be in the range of 1.1 billion-3.6 billion mt per year.

Wildfires burning in radioactively contaminated vegetation lead to uncontrollable redistribution of radionuclides, e.g., the long-living radionuclides caesium (^{137}Cs), strontium (^{90}Sr), and plutonium (^{239}Pu). In the most contaminated regions of Belarus, Russian Federation, and Ukraine, the prevailing forests are young and middle-aged pine and pine-hardwood stands with high fire danger classes. In 1992, severe wildfires burned in the Gome region (Belarus) and spread into the zone of 30 kilometers (km) radius around the Chernobyl Power Plant. Research reveals that in 1990 most of the ^{137}Cs radionuclides were concentrated in the forest litter and upper mineral layer of the soil. In the fires of 1992, these radionuclides were lifted into the atmosphere. Within the 30-km zone, the level of radioactive caesium in aerosols increased 10 times (Dusha-Gudym 1996).

Combustion Products

The immediate effects of burning are the production and release of gases and particulates into the atmosphere, affecting its chemistry. The instantaneous aerial combustion products of burning vegetation include carbon dioxide, carbon monoxide, methane, nonmethane hydrocarbons, nitric oxide, sulfur oxide, methyl chloride, polycyclic aromatic hydrocarbons, and other gases that are released and returned to the atmosphere in a matter of hours. The greenhouse gases, viz. carbon dioxide and methane, influence global climate, while combustion particulates also affect global radiation. Methane, nonmethane hydrocarbons, and nitric oxide are all chemically active gases that affect the oxidizing capacity of the atmosphere and lead to the photochemical production of ozone in the troposphere. Recently, it was discovered that biomass burning is also an important global source of atmospheric bromine in the form of methyl bromine. Bromine leads to the chemical destruction of ozone in the stratosphere and is about 40 times more efficient in the process than chlorine on a molecule-to-molecule basis. Burning also enhances the biogenic emissions of nitric oxide and nitrous oxide from soil. Biomass burning affects the reflectivity and emissivity of the earth's surface as well as hydrological cycle by changing rates of land evaporation and water run off (Crutzen and Goldammer 1993; Goldammer 1993a; and Anon 1997a, 1998).

Combustion products are a significant source of transboundary atmospheric pollution. The smoke cloud due to fires in the Amazon area showed up on satellite images on 24 August 1995 spread over an area of 7 million km^2 covering all of Brazil's Amazon region and parts of Columbia and Paraguay. The concentration of atmospheric particle pollution in some areas in Mato Grosso, Brazil, reached 900 micrograms (µg) per m^3, three times higher than the safe level.

Social Impacts

Apart from causing transboundary air pollution, smoke emissions from wildfires affect human health, particularly causing respiratory ailments, and in some cases, disease and death.

They also cause visibility problems, which may result in a breakdown of communication systems, accidents, and economic loss. Other social impacts include damage to energy and electric installations, disruption in the supply and distribution of food, displacement of people from affected areas, and temporary closure of educational establishments and production units.

Air Quality and Health

The main constituent of the smog that adversely affects health is particulate matter. The "WHO [World Health Organization] Health Guidelines for Episodic Vegetation Fire Events" that arose from the meeting of experts held in Lima, Peru, 6-9 October 1998, stressed the necessity of ground-based air quality monitoring of particulate matter in all countries affected by regional haze from vegetation fires. Ideally, $PM_{2.5}$ (particulate matter with an aerodynamic diameter less than 2.5 microns) should be measured since that size fraction has a significant health impact. If that is not possible, PM_{10} or total suspended particulates (TSP) should be measured. The WHO draft document also recommends that additional pollutants such as ozone, nitric oxide, sulfur dioxide, carbon monoxide, aldehydes, and polyaromatic hydrocarbons be measured, if possible, to provide a comprehensive assessment of the health risks resulting from exposure to haze components. Measurement of carbon monoxide, carbon dioxide, and TSP would also allow some partitioning of smoke into flaming and smoldering sources and evaluation of the biomass particulate conversion ratio.

As the concentration of airborne particles rises, a corresponding rise in hospital admissions (and even deaths) is noted. Even though evidence is piling up increasingly on the lethal effects of particles, scientists are yet to fathom the extent of damage they can cause to public health. (See Boxes 2 and 3.)

Economic Impacts

Fire is one of the least expensive and simplest tools for preparing land for growing agricultural crops. However, once out of control, it can lead to long-term site degradation and other detrimental impacts. Fire can thus be a source of positive and negative impacts—the reason why rural societies

Fire can be a source of positive and negative impacts—the reason why rural societies considered fire as a good servant, but a bad master

BOX 2 The Air Quality Standards for PM_{10} Set by International Agencies

Agency	Standard	Time Period
ALA (proposed)	10 µg/ m³	Annual average
ALA (proposed)	18 µg/ m³	24-hour average
US EPA	50 µg/ m³	Average annual ambient standard
US EPA	150 µg/ m³	24-hour average
United Kingdom	50 µg/ m³	24-hour average
Indian Standard	60 µg/ m³	Annual average
WHO	70 µg/ m³	24-hour average (European Ambient Air Quality Guideline)

Note: All figures in micrograms per cubic meter (µg/m³).
Source: Deadly Particles, *Down to Earth*, 15 December 1999.

BOX 3 **Pollution and Mortality**

Possible biological mechanisms by which pollution causes death include the following:

- increased susceptibility to infection from impaired immune defenses;
- airways inflammation leading to impaired gas exchange and hypoxia (deficiency of oxygen reaching the tissues of the body);
- provocation of alveolar inflammation by ultrafine particles with the release of mediators that exacerbate underlying lung diseases and increase blood coagulation;
- increased lung permeability leading to pulmonary edema (excessive accumulation of fluid on the lung tissues); and
- precipitation of heart failure in those with chronic heart disease by acute bronchitis or pneumonia induced by pollution.

Source: *Particles in Our Air: Health Effects and Concentrations*, edited by Richard Wilson and John Spengler, Harvard University Press, US, 1996.

considered fire as a good servant, but a bad master.

Apart from loss of material goods and services, forest fires cause serious direct economic losses through damage and decline in the quality of forest growing stock, reduced landscape stability, increased proneness to pests and diseases, reduced availability of forest-based raw material supplies, and the need for new investments in forest rehabilitation and fire protection. Indirectly, they affect agricultural productivity and tourism, indigenous populations and their means of livelihood, and jeopardize the prospects and ability of the rural poor to improve their standard of living.

Forest fires can also degrade other surviving forests by exerting impact on their composition, regeneration, productivity, protection functions, soil quality, wildlife, and aesthetics.

By 1990, conversion of tropical forests—much of it accomplished by open burning—had reached an estimated rate of 1.8 percent of the earth's total forestland per year

Fire in Land and Forest Management

Controlled use of fire has been an important aspect of land and forest management. Methods and techniques have progressively evolved to suit the types of land and the nature and scale of operations, covering all aspects of fire management—prevention/protection, mitigation, suppression, damage control, and rehabilitation. There have been considerable improvements in fire management techniques, mainly in industrialized countries, through the use of sophisticated tools and equipment.

While land clearing for agriculture and estate crops has taken place on an increasing scale, a new dimension was added to forest management around the middle of the 19th century, when tree plantations were raised under a system of clear felling the natural forests and artificially regenerating them—essentially for commercial and industrial purposes. The commercial potential of the tropical forests also promoted increased rates of extraction; and the conventional and conservative "selection systems" in many cases were deliberately set aside (or diluted).

Since the beginning of the industrial revolution, humans have transformed about 40 percent of the earth's land surface. By 1990, conversion of tropical forests—much of it accomplished by open burning—had reached an estimated rate of 1.8 percent of the earth's total forestland per year. In absolute terms, this amounts to about 14.2 million ha. The implications of open burning on this scale for the global environment are startling.

A healthy forest is one that is resilient to changes. The term ecosystem health is used to define the structural and functional stability of an ecosystem and its ability to bounce back after stress (Gupta and Yunus 1998). Forest fire management is an important aspect of sustainable forest management, ensuring the health of forest ecosystems, and that negative impacts of fire are minimized and positive impacts maximized.

Fire Science and Technology

The years since World War II, particularly the recent past, have witnessed a series of achievements in the field of fire management science and technology. More are in different stages of development. Most remarkable progress has been made in the following fields.

Detection and Monitoring of Fires

The amount of living vegetation, and its moisture content, has a strong effect on the propagation and severity of wildland fires. Observation and assessment of vegetation greenness is therefore essential for any system of fire danger rating. Current assessment of living vegetation moisture relies on various methods of manual sampling. While these measurements are quite accurate, they are difficult to obtain over broad areas, so they fail to portray changes in the pattern of vegetation greenness and moisture across the landscape.

Space-borne remote sensing technologies have improved the capability to identify fire activities at local, regional, and global levels by using visible and infrared sensors on existing platforms for detecting temperature anomalies, active fires, and smoke plumes.

Polar orbiting weather satellites provide the potential for delivering greenness information and other parameters needed for fire management and fire impact assessment with daily global coverage at coarse spatial resolution. This is achieved using wide-angle scanning radiometers with large instantaneous fields of view.

Short-return interval, low-resolution geosynchronous satellites such as the Geosynchronous Operational Environmental Satellite (GOES) (Prins and Menzel 1996) and polar orbiting sensors such as the NOAA AVHRR (European Commission 1996, Justice et al. 1996, Kendall et al. 1996) have been used successfully to establish calendars of vegetation state (fire hazard) and fire activities. Other satellites with longer temporal sampling intervals, but with higher resolution, such as LandSat, the French Earth Resource Satellite, SPOT, and space-borne radar sensors, deliver accurate maps of active fires, vegetation state and areas affected by fire. Because of its availability, spatial resolution, spectral characteristics, and low cost, NOAA AVHRR has become the most widely used satellite data set for regional fire detection and monitoring. Currently, AVHRR data are used for vegetation analyses and in the detection and characterization of active flaming fires, smoke plumes, and burn scars.

The middle-infrared and thermal AVHRR bands of the NOAA polar-orbiting satellites have been used for identifying fires.[4] Several techniques are used to detect active fires on regional scales using multispectral satellite data. A comprehensive validation of AVHRR active fire detection techniques through a range of atmospheric and surface conditions has not yet been performed. Several studies, however, have provided some level of validation.

Polar orbiting weather satellites provide the potential for delivering greenness information and other parameters needed for fire management and fire impact assessment with daily global coverage at coarse spatial resolution

Limitations of AVHRR Fire Detection

Data are sensed by all channels simultaneously at 1.1 km spatial resolution. Data acquired by the instrument are resampled on board the satellite to 4 km spatial resolution and recorded for later transmission to one of the two NOAA Command Data Acquisition (CDA) stations, at Gilmore Creek, Alaska, and Wallops Island, Virginia. This is known as the Global Area Coverage mode of transmission. In addition, the full spatial resolution 1.1 km data can be recorded for previously scheduled areas of the world, in the Local Area Coverage mode, or can be received directly from the satellites by suitably equipped receiving stations in the High Resolution Picture Transmission mode.

Even in full configuration, with two NOAA satellites in operation, the AVHRR data provide only a limited sampling of the diurnal cycle. The orbital characteristics of the satellites result in two daytime and two nighttime orbits per location. The afternoon overpass provides the best coverage in terms of fire detection and monitoring in tropical and subtropical regions (Justice and Dowty 1994). In addition, the afternoon overpass enables detection of the full range of parameters described (i.e., vegetation state, active fires, burn scars, smoke).

Perhaps the most fundamental problem of AVHRR fire detection is that analysis is limited to relatively cloud-free areas. This can be a serious issue in tropical and subtropical regions. Cloud cover can cause an underestimation in the extent and frequency of burning, and limits the ability to track vegetation parameters. This issue is not limited to the NOAA satellite system. Dense clouds will prevent detection of the surface by all visible and infrared sensors. A satisfactory methodology for estimating the amount of burning missed through cloud obscuration has yet to be developed.

Improved fire weather forecasts are needed for forest fire management at various time and space scales

With the characteristics of the NOAA meteorological satellites, as described, it is possible to collect near real-time information to support fire management activities. (A fully automatic system has been developed to detect forest fires using data from NOAA AVHRR. The prototype system was developed in Finland and tested in four experiments in 1994 to 1997 there and in its neighboring countries).

Fire Weather and Seasonal Moisture Changes

Since 1989, the use of a Normalized Difference Vegetation Index (NDVI) to monitor seasonal changes in the quantity and moisture of living vegetation has been investigated (Goward et al. 1990). Daily AVHRR data are composited into weekly images to remove most of the cloud and other deleterious effects, and an NDVI image of the continental US is computed by the US Geological Survey's Earth Resources Observation Systems (EROS) Data Center. These weekly images are obtained via the Internet and further processed into images that relate to fire potential (Burgan et al. 1996) and easily interpreted by fire managers. Four separate images are derived from the NDVI data—Visual Greenness, Relative Greenness, Departure from Average Greenness, and Live Shrub Moisture.

To improve the determination of spatial definition of fuel types requires use of a fire danger fuel model map. In the United States, the EROS Data Center has used a series of eight monthly composites of NDVI data for 1990 to produce a 159 class vegetation map of the continental United States at 1 km resolution (Loveland et al. 1991). Data from 2,560 fuel observation plots randomly scattered across the country have permitted the development of a 1 km resolution fuel model map from this. This is now being used to provide broad-scale fire danger maps.

Improved fire weather forecasts are needed for forest fire management at various time and space scales. At large time and space scales, accurate fire weather forecasts have the potential for long-range planning of allocation of scarce resources; at smaller time and space scales they have potential use in alerting, staging, and planning the deployment of fire suppression crews and equipment; at the smallest time and space scales, they can be helpful in fighting fires as well as determining optimal periods for setting prescribed silvicultural fires (Fosberg and Fujioka 1987; Roads et al. 1991, 1997).

Current US fire weather forecasts are prepared from short-range weather forecasts (one or two days) from the US National Center for Environmental Prediction (NCEP), other model output statistics, and human judgment. These fire weather forecasts include information about rainfall, wind, humidity, and temperature.

An experimental modeling system, developed at the NCEP for making short-range global to regional weather forecasts, is being developed at the Scripps Experimental Climate Prediction Center (ECPC). Although this system is focused on making and disseminating experimental global to regional fire weather forecasts for Southern California, it could easily be transported and applied anywhere else in the world.

Circulation Models

Global Circulation Models allow the integration of information crucial for assessing fire danger in a regionally or globally changed climate. This has been proven successfully for the boreal zone (Stocks and Lynham 1996, Stocks et al. 1997) and partially for tropical fire regimes (Goldammer and Price 1998).

Burned Area and Emission Estimates

The demands of forest inventory, land-use planning, and atmospheric chemistry studies require accurate knowledge of the amount of vegetation affected by fire, and the types of plants burned. High- and low-resolution sensors have proven successful in establishing reliable data sets on burned areas on a regional scale (Cahoon et al. 1994) and offer the opportunity to extend this method on a global scale.

Technology Development

The integration of remotely sensed fire data with information obtained on the ground in geographic information systems (GIS) is increasingly being used in fire management-oriented systems (Chuvieco 1996). Remotely operated air vehicles (drones) offer reliable and safe means of information gathering for disaster-type fire situations.

A high-quality climate database is a prerequisite for modeling, including initialization, testing, and verification. Hazard ratings, haze monitoring, and prediction also require good knowledge of the state of the atmosphere, which can be provided only by meteorological observations of high quality (Tapper et al. 1998).

Communication systems for early warning information dissemination are generally advanced since they rely on the technology developed in the civilian telecommunication sector. Space-borne sensing and collection of real-time data for early fire warnings generally depend on systems that were not specifically designed for sensing fire precursors, active fires, and fire effects. A short overview of the most important sensors that are in use or are being built gives an indication of future possibilities.

New Space-Borne Sensors

Remote sensing users, in addition to continuing experimentation and refinement of methods, need to provide operational monitoring data sets on regional and global scales to contribute to early warning of fire hazards, and to fire and smoke management. The development of operational automated monitoring techniques and the provision of consistent long-term data sets are challenges to be faced. Issues such as prohibitive costs of data, computing resources, data management, data archival, and distribution also need to be addressed.

Data set development is being undertaken using satellite sensing systems, which, as stated

The development of operational automated monitoring techniques and the provision of consistent long-term data sets are challenges to be faced

Several international statements, commitments, and declarations on development and sustainable forest management have flagged the need to mitigate and manage forest wildfires

earlier, were not designed for fire monitoring. The current suite of sensors suitable for fire monitoring have problems such as calibration, saturation, spatial resolution, orbital overpass time, and coverage, which need to be taken into account in data processing and data set compilation. It is critical that users fully understand the limitations of the data and their utility. New sensors are being designed and built that will reduce or eliminate some of these problems, but they will introduce new, and in some cases, unanticipated, ones instead. The development of new satellite data sets is an iterative process that needs to be undertaken in close collaboration with the users. The planned systems will provide a challenge in terms of presenting the amount of raw data in a suitable volume and level of information content (Goldammer 1998b, IDNDR 1997). New sensors being developed, such as the Moderate Resolution Imaging Spectroradiometer, are aimed at satisfying the demands of fire science and management.

Challenges

Early warning, monitoring, and inventory of wildfires need to be accompanied by monitoring and inventory of ecological characteristics that lead to fire. Disturbances, such as insect or disease outbreaks, wind throw of trees, industrial forestry, and conversion of forests to other uses are frequently precursors to fires.

Pests and diseases stress ecosystems, resulting in production of dead matter, particularly foliage and other fine materials that are critical to fire ignition and behavior. Post-fire vegetation recovery is important to predict fire-return intervals. Advanced early warning systems will need to integrate these parameters into multilayer fire information systems. GIS technology, combined with decision support systems (expert systems), offers feasible, cost-efficient, and user-friendly solutions (Goldammer 1998b, IDNDR 1997).

Modern Fire Suppression Technologies

These include aircraft, communication equipment, fire-retardants, heavy field equipment, fire jumping, and water bombing. They have seen limited use in developing countries, however.

International Actions

At the international level there is considerable interest in forest fires and haze, particularly transboundary implications, and their impact on the environment.

Expressions of World Concern

There has been increasing global concern at the deterioration of the environment, including deforestation and resource depletion. A series of international conferences, summits, and commissions, starting with the United Nations (UN) Conference on the Human Environment held in Stockholm in 1972, have unequivocally stated that without environmental conservation, development will not be sustainable. In this connection, the crucial issue of deforestation and the need to obviate the undesirable impacts of wildfires have also been stated, implicitly or explicitly. The widespread fires seen in many countries during the 1990s—particularly those of 1997-1998—and the associated atmospheric haze pollution and negative socioeconomic impacts provided an unprecedented urgency for dealing with fires.

The Declarations

Several international statements, commitments, and declarations on sustainable development and forest management have flagged the need to mitigate and manage forest wildfires, in the context of controlling deforestation and forest degradation.

The Antalya Declaration

The Antalya Declaration of the XIth World Forestry Congress (WFC), 13-22 October 1997, singled out forest fires for special attention. Noting with alarm the continued rate of forest loss and degradation in many regions of the world, the Congress called upon countries "to develop, implement, and review policies, plans, and management practices aimed at minimizing the destructive nature and extent of wildfires on forestlands" (WFC 1997).

The Rome Declaration

The Rome Declaration on Forestry was adopted at the Second Ministerial Meeting on Forestry, in Rome, 8-9 March 1999. At that meeting, the ministers responsible for forests:

- were deeply concerned at the important challenges associated with forest loss and degradation in many regions;
- stressed the need to maintain the integrity of forests as ecosystems by promoting sustainable forest management worldwide;
- noted that the causes of forest fires are many and complex; and
- recognized the need to harness all efforts to prevent forest fires as well as to address the multiple causes and consequences of fires around the globe.

They also called upon the UN Food and Agriculture Organization (FAO) and other international organizations, donor agencies, and concerned countries to work together to address the underlying causes of forest fires; to improve the coordination of efforts to tackle, prevent, and combat forest fires; and to rehabilitate affected areas with a view to providing assistance requested by governments.

On their part, the ministers pledged:

- to work together toward a constructive and forward-looking outcome for the global forest policy dialogue at the eighth session of the United Nations Commission on Sustainable Development;
- to better coordinate and strengthen efforts to prevent, manage, monitor, and suppress forest fires, especially in anticipation of the next *El Niño* and, in the longer term, to address the underlying causes of forest fires; and
- to work closely with counterparts in other ministries in the respective countries to promote cross-sectoral policies and activities that support sustainable forest management.

Such pledges should be followed up seriously.

Conventions

Although some international environmental treaties date back to the early part of the 20th century, it was not until the 1960s that concerns about environmental pollution and depletion of natural resources led to binding multilateral environmental agreements. The following conventions have had direct or indirect implications for the way the fires are managed and controlled:

Ramsar. Convention on Wetlands of International Importance especially as waterfowl Habitat (Ramsar Convention), Ramsar, 2 February 1971. www.ramsar.org

World Heritage. Convention Concerning the Protection of the World Cultural and Natural Heritage, 23 November 1972. www.unesco.org/whc

CMS. Convention on the Conservation of Migratory Species of Wild Animals, Bonn, 23 June 1979. www.wcmc.org.uk/cms

Ozone. Vienna Convention for the Protection of the Ozone Layer, Vienna, 22 March 1985, and Montreal Protocol on Substances

Conventions have had direct or indirect implications for the way the fires are managed and controlled

Nonbinding instruments are often forerunners of binding policy instruments and have at times had a more profound effect on environmental policy than binding ones

that Deplete the Ozone Layer, Montreal, 16 September 1987. www.unep.org/ozone

UNFCCC. United Nations Framework Convention on Climate Change, New York, 9 May 1992. www.unfccc.de

CBD. Convention on Biological Diversity, Nairobi, 22 May 1992. www.biodiv.org

UNCCD. United Nations Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, Paris, 17 June 1994. www.unccd.de

Another multilateral environmental agreement that emerged after the 1972 Stockholm Conference on Environment was the 1979 Convention on Long-Range Transboundary Air Pollution, adopted by many European states, Canada, and US (UNEP 1999). Signatories have adopted a critical loads approach under the convention, which relates to the transboundary effects of haze from land and forest fires in Southeast Asia (see Box 4).

Nonbinding Instruments

Nonbinding instruments are often forerunners of binding policy instruments and have at times had a more profound effect on environmental policy than binding ones. Two nonbinding instruments adopted during the UN Conference on Environment and Development (UNCED) held in Rio de Janeiro in 1992 are the Rio Declaration and Agenda 21 (UNCED 1993). The Forest Principles[5] adopted at UNCED falls under this category.

UN International Decade for Natural Disaster Reduction

On 11 December 1987 at its 42nd session, the General Assembly of the UN designated the 1990s as the International Decade for Natural Disaster Reduction (IDNDR). The basic idea behind this proclamation was the unacceptable and rising levels of losses that disasters continue to incur on the one hand. And on the other hand, there was the existence of a wealth of scientific and engineering know-how that could be effectively used to reduce losses resulting from disasters.

The UN World Conference on Natural Disaster Reduction, which was part of a midterm review of IDNDR activities, was held in Yokohama, Japan, on 23-27 May 1994. The UN

BOX 4 Convention on Long-Range Transboundary Air Pollution

The Convention on Long-Range Transboundary Air Pollution (LRTAP) in Europe, which was signed in 1979 and entered into force in 1983, is a classic example of regional environmental management. The first protocols organized finance and addressed acidification and photochemical pollution. Acidification was addressed again in 1994 since it was found that the first sulfur protocol did not provide sufficient protection. Recent attention has focused on the problems caused by persistent organic pollutants and heavy metals. Future priorities include development of an innovative, multi-effect, multi-pollutant protocol aimed at nitrogen oxides and related substances, which will include protection of the environment as well as human health.

Participating countries commit themselves to periodic reporting on emissions, national strategies, and programs. Many participating countries have developed action plans or long-term strategies based on a system of cost-effective, differentiated obligations.

Clear financing, the involvement of national scientific bodies, and joint implementation have contributed to LRTAP's status as one of the most successful regional multilateral environmental agreements. Emissions of acidifying substances have decreased in all areas since the first protocols came into force. The decrease is greatest for sulfur dioxide, the pollutant causing the major problem, with expected national reductions in 2000 relative to 1980 of about one third in Central and Eastern Europe, and two thirds to three quarters in Western Europe. However, reductions of the emissions of nitrogen oxides, ammonia, and hydrocarbons are more difficult to achieve. This will be the subject of a new protocol. To exploit the advantages of the multi-effect, multi-pollutants approach, sulfur emissions will also need to be further reduced. This should increase the cost-effectiveness of controlling air pollution for all participating countries.

Source: UNEP 1999.

BOX 5 Wildfire '97—Principles and Needs

Principles

- Fire is a key element of sustainable development.
- Fire is a component of ecological processes.
- Fire is both a threat and a tool.
- Fire and its effects are not constrained by geographic or political boundaries.
- Fire is one of the few natural disturbances that can be forecasted and mitigated.
- Fire may endanger people and communities.
- Fire can disrupt local economies.
- Fire can cause irreversible impacts.
- Fire is an important element of most global ecosystems and atmospheric processes.
- Fire's role in the global environment is not fully understood or appreciated.

Needs

- Increase awareness of the impact of fire on sustainable development.
- Incorporate wildland fire into land management policies.
- Compile international data on wildland fire.
- Expand our understanding of fire's role in global processes.
- Establish international partnerships and agreements.
- Coordinate international research.
- Continue international dialogue.
- Implement appropriate technology.
- Share information, knowledge, and experience.
- Evaluate international progress in wildland fire management.

(Based on the report of the International Conference on Wildfire '97, Vancouver, Canada, May 1997).
Source: Goldammer 1997b.

team of specialists used the opportunity to express their views on global fires. In 1997, close links were established between the IDNDR Secretariat in Geneva and the Global Fire Monitoring Center (GFMC).

In July 1997, GFMC was entrusted with the formation of a Working Group on Fire and Related Environmental Hazards of the IDNDR Early Warning Programme. The recommendations of the group, which were submitted to IDNDR in 1997, were incorporated into the Report of the UN Secretary General: "Improved Effectiveness of Early-Warning Systems with Regard to Natural and Similar Disasters" (Goldammer 1998b).

The proposed priority activities of the Working Group on Fire and Related Environmental Hazards include Global Fire Inventory, Information Exchange and Technology Transfer, Fire Research and Policies, and Agreements on Environmental Protection.

Scientific Programs

Fire research and technology development has received considerable stimulation from scientific projects conducted under the umbrella of the International Geosphere-Biosphere Program (IGBP) and other programs devoted to global change research (Andreae et al. 1993, FIRESCAN Science Team 1996, Malingreau and Justice 1997, Van Wilgen et al. 1997). While the scope of global change research is not necessarily directed toward operational management systems, e.g., early warning of natural hazards, the spinoffs of science nevertheless have considerable potential for contributing to management solutions.

However, the application of technologies and methods of information gathering, processing, and distribution has revealed that many existing systems must be further developed to meet the requirements of precise and real-time application for early warning and management of fire and other environmental hazards.

IGBP at the Max Planck Institute for Chemistry, Freisburg, Germany, provides the basis for interdisciplinary fire research programs. One of the operational IGBP core projects is the International Global Atmospheric Chemistry (IGAC) Project, which is investigating the impact of biomass burning on the atmosphere and biosphere (BIBEX). Since 1990, interdisciplinary international research campaigns have been conducted or are

The application of technologies and methods of information gathering, processing, and distribution has revealed that many existing systems must be further developed to meet the requirements of precise and real-time application for early warning and management of fire and other environmental hazards in the planning and implementation stage, the most important of which in the tropics are the Southern Tropical Atlantic Regional Experiment (STARE) and the Southeast Asian Fire Experiment (SEAFIRE) (see Chapter 3).

STARE was designed to investigate the atmospheric chemical consequences of fires in tropical and subtropical forests and savannahs of South America (Brazil) and Southern Africa. This first intercontinental fire experiment was conducted in the field during 1992 and involved more than 150 fire researchers from 14 nations. It demonstrated that fires on both sides of the tropical Atlantic cause elevated ozone concentrations in the troposphere during the dry season (August-November). The Southern African Fire-Atmosphere Research Initiative (SAFARI) was the African part of STARE and included fire ecology research components at a subcontinental level. In 1996-1997, additional international fire research programs were conducted in near-equator Africa.

SEAFIRE will investigate the characteristics and regional and global transport of emissions from various types of fire in tropical Southeast Asia

SEAFIRE will investigate the characteristics and regional and global transport of emissions from various types of fire in tropical Southeast Asia, such as fires used in forest conversion and shifting cultivation, and in grassland and seasonally dry monsoon forests (Goldammer 1996).

Previous and current international fire experiments under the IGBP are regularly announced in the UN-ECE/FAO *International Forest Fire News* (*IFFN*) and also published in scientific media (e.g., *Journal of Geophysical Research*).

International Exchanges

The international community of fire specialists started to organize itself in the late 1980s. With the first issue of *IFFN*, published by the Economic Commission for Europe (ECE)/FAO Agriculture and Timber Division (now Timber Section, UN-ECE Trade Division) in 1988, a steadily increasing communication process in international fire matters was initiated. It was followed by the publication of the first scientific periodical, *Journal of Wildland Fire*, and the foundation of the International Association of Wildland Fire (IAWF) in 1992. This association provides the latest information on wildland fire issues through the journal as well as through *Wildfire* (a quarterly magazine), *Current Titles in Wildland Fire* (a monthly bulletin available on disk or printed that lists new articles, videos, and books on wildland fires), a continuously updated *International Directory of Wildland Fire* (a digital master list of 30,000 people working in the field), and an *International Bibliography of Wildland Fire* (a digital product with more than 45,000 citations on wildland fire). IAWF cosponsors fire conferences, sells and distributes publications, and provides free access to databases by telephone, fax, or E-mail (http://www.neotecinc.com/wildfire). Quick information through the Internet is provided by FireNet (http://life.anu.edu.au/landscape-ecology/firenet/firenet.html).

A series of international fire conferences has provided regular platforms for presenting and exchanging scientific results; for example:

- the biannual Conference on Fire and Forest Meteorology (formerly held in Canada and the United States, and beginning with the Australian conference in 1996 also internationally);
- the International Conference on Forest Fire Research at Coimbra University (Portugal), in 1998 for the first time in conjunction with the 14th Conference on Fire and Forest Meteorology; and
- the ECE/FAO seminars on forest fires (held at five-year intervals since 1981).

Fire management science and technology have reached a level of advancement and sophistication in industrialized countries. But in developing countries, they are still in their nascent stage, as most do not have adequate infrastructure, experience, and hardware to manage wildfire disasters.

Although bilateral assistance agreements exist and several field projects in fire management are carried out through national and international organizations, there are no facilities and/or mechanisms available to provide the necessary disaster management assistance internationally on a permanent and quick-response basis.

Besides the ECE/FAO Team of Specialists on Forest Fire, which has a restricted mandate and a regionally restricted area of influence, and some ongoing and planned regional fire research campaigns under the IGBP scheme, neither the UN system nor any other organization is providing adequate structures and mechanisms with global responsibilities in fire management.

Consequently, an information and monitoring system was needed that national and international agencies involved in land use planning, disaster management, or other fire-related tasks could utilize for planning and decision making. To fill the need, the Global Fire Monitoring Center (GFMC) was established in June 1998 in accordance with the objectives of the UN/IDNDR, recommendations of the International Tropical Timber Organization (ITTO) Guidelines on Fire Management in Tropical Forests, and recommendations of various scientific and policy conferences in the field of fire.

GFMC is located at the Fire Ecology and Biomass Burning Research Group of the Max Planck Institute of Chemistry, Germany. GFMC has established regional activities linked to Monitoring Tropical Vegetation.

For its first phase, GFMC is sponsored by the German Government's Ministry of Finance Affairs, as the country's contribution to the IDNDR. GFMC is also cosponsored by several international and national organizations; UN-ECE Trade Division; IDNDR; International Union of Forestry Research Organizations (IUFRO); International Bureau of Forest Research Association; IGBP; and US Bureau of Land Management. The fire documentation, information, and monitoring system is accessible through the Internet: http:/www.uni-freiburg.de/fireglobe.

International Guidelines

Fire Management Guidelines

ITTO has established a set of international guidelines for the protection of tropical forests against fires. This resulted in a publication, *ITTO Guidelines on Fire Management in Tropical Forests*, in 1996. The *Guidelines* contains 29 principles and recommendations covering: policy and laws, strategies (fire management planning, fire management options, fire suppression, role of communities in fire protection), monitoring and research, institutional framework and capacity development, socioeconomic considerations, land resources management, and training and public education. The *Guidelines* offers a framework for countries in the tropics, to be fine-tuned in accordance with socioeconomic, cultural, and vegetation conditions.

> The International Tropical Timber Council has established a set of international guidelines for the protection of tropical forests against fires

Health Guidelines

As a consequence of the 1997-1998 fires and haze, several international agencies have undertaken important initiatives. One issue that attracted attention was the health affects of smoke from vegetation fires. To address this, WHO has prepared *Health Guidelines for Episodic Vegetation Fire Events*.

Notes

[1] Montane climate/vegetation influenced by altitudinal zonation is not included here.

[2] The residual product of rock decay.

[3] Zonal soils that develop in a moist climate.

[4] The satellite can detect fire points, normally called hot spots. It, however, was developed for weather and oceanic monitoring, both of which have temperatures below 40°C. The sensor measures the average temperature of 1 km^2. This does not mean that a fire has to be of this size, since a small hot fire can influence the average temperature of the 1 km^2 pixel considerably. Unfortunately, detecting hot spots is not flawless. Bare soil, corrugated iron, and low vegetation (grass) can also have a high temperature in the sun and are often wrongly assigned as a fire hot spot. This misclassification can account for more than half of results. Further, hot spots cannot be detected in areas with thick haze or smoke cover, as the sensor cannot penetrate haze, smoke, or cloud. Area calculation is difficult or impossible with only hot spot information.

[5] Full title: A nonlegally binding statement of principles for a global consensus on the management and conservation and sustainable development of all types of forests.

CHAPTER 2

Forest Fires and Haze in the ASEAN Region

[This chapter focuses on forest fires and haze in the ASEAN region, and provides a detailed analysis of the causes and constraints that exacerbate these problems. Forestland conversion involving uncontrolled use of fire has been identified as a prime cause and source of forest fires. The social, economic, and environmental impacts of the recent forest fires and haze have been enormous, with the estimated total cost of the 1997-1998 occurrences alone amounting to $9.3 billion.]

The Background

Nearly half of the ASEAN[6] region is covered with tropical forest, accounting for about 6 percent of the forest area of the world. The region's forests have global significance in terms of biological diversity (FAO 1999a). ASEAN is an important timber producing region (particularly of tropical hardwoods), accounting for 6 percent of the world's industrial roundwood production. More than 85 percent of this comes from Indonesia and Malaysia. These two countries are major producers and exporters of wood-based panels (mainly plywood), together accounting for 34 percent (in value) of world export trade in panels. Three quarters of total wood production is used as fuelwood and charcoal. In addition, the region is rapidly developing a substantial pulp and paper industry. Many ASEAN member countries (AMCs) are also major exporters of nonwood forest products (NWFPs), in particular rubber, rattan, and bamboo.

Smoke emanating from plantation sites, as seen through satellite imaging, Indonesia, 1997.

Photo: ASEAN Specialized Meteorological Centre, Singapore

The amount of land under forest in the ASEAN region is 46.2 percent and forest area per capita is 0.4 ha. The rate of deforestation in the region has been substantial, at about –2.8 million ha during 1990-1995, representing an annual change of –1.3 percent.

Forests have supported overall economic development in AMCs by generating investment funds and providing land for the expansion of agriculture and estate crops. The need for increasing export earnings and other national economic development imperatives has prompted the conversion of forestlands into rubber, oil palm, and timber plantations. Fire has been used extensively in land preparation as a cost-effective process (see Box 6).

As a result of these and other factors, all AMCs are prone to wildfires, which are likely to remain a serious threat for some time. As a partnership for sharing experiences, information, responsibilities, and benefits, and

BOX 6 **Land Conversion and Economic Development**

Conversion of forest and wildlands to other productive uses is a prominent feature of the national economic development policy in a number of forest- and land-abundant ASEAN countries, just as it formed an important part of the economic development process of all countries that today enjoy a high level of income (i.e., the developed economies of Europe, North and South America, and Oceania). As in the case of these latter economies, the land conversion process is essentially complete in some AMCs (Brunei Darussalam, Philippines, Singapore, and Thailand).

In others (Indonesia and Malaysia), land conversion is taking place, and is seen by policymakers as an important and positive contribution to economic development. In yet other AMCs, land conversion is experiencing a hiatus as a result of previous political and economic dislocations (Cambodia and Viet Nam). Land conversion in these countries may, therefore, resume in the future when the pace of economic development quickens sufficiently. In still other AMCs (the Lao People's Democratic Republic [Lao PDR] and Myanmar), a significant amount of land remains in an undisturbed state, which means that national development policymakers in these countries have the option of using large-scale land conversion to help fuel future economic development.

Land conversion is undertaken in order to harness the wealth contained in land resources so that it directly and immediately enters into the flow of production and national income. Once brought into this flow, this wealth can easily be transformed into goods and services of all types. Some of this land wealth is transformed into investment in future productive capability, which stimulates employment and ultimately augments national income. Some of the remainder is used to purchase consumption goods, which in part increases the demand for home-produced goods, indirectly stimulating further domestic investment and employment.

But land conversion can support real development only if it can be carried out without damaging the environment. One of the major causes of Indonesia's 1997-1998 wildfires, identified by investigators, was the land clearing practices of oil palm plantations companies and smallholders, who used fire as a low-cost (or free) way of preparing land for cropping. More than 60,000 ha of forestland per year were converted into oil palm between 1995 and 1997. Most of the oil palm plantations were opened up through systematic burning of vegetation, primarily logged-over forest. In addition to the existing 2.4 million ha, the Indonesian Government intends to allocate another 3.1 million ha for future conversion into oil palm plantations.

Regulations allow for three kinds of land-clearing permits: open burning, controlled burning, and zero burning. However, landowners and companies are generally reluctant to adopt more expensive zero-burn land preparation systems. This is also true of forest plantations.

Source: ADB/ASEAN (1999). Final Report of RETA 5778: *Strengthening the Capacity of the ASEAN to Prevent and Mitigate Transboundary Atmospheric Pollution*.

working toward common good, ASEAN is in a strong position to address its fire problem at the regional level.

Similarities and Differences between AMCs

There are several differences and similarities between AMCs. The differences in geographic location, in terms of latitudes and longitudes, geological evolution, physiographic and topographic aspects, volcanism, wind direction, etc., are reflected in their climate, vegetational types, land categories, resource endowments, and capabilities. The diverse ethnic and historical background (including the history of colonization), coupled with the nature of resources available, has also resulted in differences in such aspects as religion, culture, political system, demographic features, level of economic development, and share of international trade.

Because of the proximity and contiguity of these countries, an underlying "unity in diversity" has developed in social and economic attitudes, resulting from migration, trade, and sociocultural interaction. Accordingly, there are considerable similarities in land-use practices, economic activities, social habits, commercial dealings, and international interests. In spite of the differences in the level of industrialization, agriculture continues to be important to all AMCs, with the exception of Brunei Darussalam and Singapore.

The entire ASEAN region generally falls within the tropical zone and follows comparable land management systems.

ASEAN is in a strong position to address its fire problem at the regional level

Fire regimes are best understood as existing along a gradient of ecological and human factors

Shifting cultivation is prevalent in all the forested countries of the region.

The rapid land use changes taking place in the countries is reflected in the high rate of deforestation. For a comparison of population, income, land, and forests of AMCs, see Table 1.

Fire Regimes of the Region

The region has a number of distinct fire regimes, each with one or more associated vegetation formations. Fire regimes are best understood as existing along a gradient of ecological and human factors. The characteristics and features of the major fire regimes are briefly described in the following sections.

Tropical Rain Forests

Tropical rain forest is the natural vegetation over large areas of Southeast Asia and the Pacific. These forests require abundant rainfall and high temperatures all year round. If monthly rainfall drops below 100 millimeters (mm), drought will result. Insular Southeast Asia, Papua New Guinea, and the high islands of Melanesia were largely covered with species-rich forests until recent decades. Logging and agricultural expansion have now greatly decreased their quality and extent. Apart from Papua New Guinea and the protected or remote parts of Southeast Asia, the lowland rain forests of the region are a mosaic of disturbed stands, fire climax grasslands, secondary vegetation, and commercial crop plantations. Within this broad climate type, special vegetation types have their own fire regimes. The fire climax *Imperata cylindrica* grasslands are fired by humans annually to prevent invasion by woody pioneer species. Peat swamp forests are susceptible to continuous subsurface burning during severe

TABLE 1 **ASEAN Region: Country Information**

Country	Land Area ('000 ha)	Pop. Density (1997 pop/km^2)	GNP per Capita	Forest Area: Area ('000 ha)	Forest Area: % of Land Area	Forest Area: Per Capita (ha)	Annual Change in Forest Area: '000 ha	Annual Change in Forest Area: % Rate
Brunei Darussalam	527	56.9	25,160	434	82.4	1.5	-3	-0.6
Cambodia	17,652	59.5	270	9,830	55.7	1.0	-164	-1.6
Indonesia	181,157	112.3	980	109,791	60.6	0.6	-1,084	-1.0
Lao PDR	23,080	22.5	350	12,435	53.9	2.5	-148	-1.2
Malaysia	32,855	63.9	3,890	15,471	47.1	0.8	-400	-2.4
Myanmar	65,755	71.2	—	27,151	41.3	0.6	-387	-1.4
Philippines	29,817	237.1	1,050	6,766	22.7	0.1	-262	-3.5
Singapore	61	5,573.8	26,730	4	6.6	NS	0	0.0
Thailand	51,089	115.7	2,740	11,630	22.8	0.2	-329	-2.6
Viet Nam	52,797	34.7	260	9,117	28.0	0.1	-135	-1.4
Total	**454,790**	**96.5**	**1,594**	**202,629**	**44.6**	**0.5**	**-2,912**	**-1.4**

— = not available.
Source: *State of the World's Forests* (FAO 1999).

droughts, and heath and limestone forests are more fire-prone than other forest types due to the limited water-holding capacity of their soils.

Undisturbed lowland rain forest is highly resistant to burning, but scientific evidence indicates that Borneo's forests (and by inference, those elsewhere) have burned periodically over tens of millennia during extreme droughts. Humans have used fires as they settled in the forests over thousands of years to create swidden[7] plots and facilitate hunting. Traditional use of fire is thought to have had little long-term ecological effect on the forests, but increased human population density, shortened fallow periods, and cash-cropping have made shifting cultivation a major agent of deforestation. Careless commercial timber harvesting has greatly increased fire hazard, and logging roads have provided agricultural settlers with access to remote forest areas, thereby increasing the risk that their land-clearing activities will result in wildfires. Logged and otherwise disturbed forests are being cleared by "slash and burn" of waste wood, in preparation for conversion to palm oil or pulpwood plantations.

Severe ENSO-related droughts over the last two decades, combined with large-scale logging in the rain forests and indiscriminate use of fire for land clearance, have led to massive wildfires in Indonesia and, to a lesser degree in neighboring countries. These have dramatically changed the fire regime, and threaten the existence of lowland rain forest flora in many parts of Sumatra and Kalimantan in Indonesia, and Sabah and Sarawak in Malaysia. The rain forest fire regime has shifted to a much higher fire frequency; larger areas have burned and fire intensity has increased. But fire policy and fire management approaches for rain forests are at an early stage of development (Whitmore 1998a, Goldammer and Seibert 1990, Schweithelm 1998b).

Tropical Lowland Deciduous Forests

This regime includes monsoon and savannah forests, the latter having less tree cover and more grass. These forests occur in areas where the dry season is three to seven months long, total annual rainfall is usually less than 2,000 mm, and the mean temperature in the coldest month is rarely less than 20 degrees C. Monsoon teak (*Tectona grandis*) forests occur naturally in continental Southeast Asia and have been planted elsewhere. Dry Dipterocarp savannah forests are also found in continental Southeast Asia, and open grasslands and thorn forests are spread in patches across drier parts of the region. The relatively dry Lesser Sunda Islands of eastern Indonesia contain monsoon and savannah forests with affinities to Australian flora. These forests usually burn one or more times in a year with low level litter, ground-level fires being the norm. Levels of fire adaptation vary among formations. Fires are typically ignited purposely or accidentally by humans, and increased frequency of burning is putting stress on these fire-adapted ecosystems (Stott et al. 1990, Goldammer 1996).

Fire Climax Pine Forests

Pine forests occur naturally on disturbed sites in the lower montane forests of tropical Asia, primarily in the Himalayan foothills, the mountains of continental Southeast Asia, Sumatra (Indonesia), and Luzon (Philippines). Human disturbance of forests at lower and higher elevations has caused the altitudinal range of fire climax pine forests to expand. Pine plantations have been established at lower elevations in many parts of the region. Tropical pine species have various levels of fire adaptation and are prone to burning due to the

The rain forest fire regime has shifted to a much higher fire frequency; larger areas have burned and fire intensity has increased

Most fires are ignited by humans through carelessness, but may be started purposely to improve grazing or help with hunting

volume and flammability of their litter. These forests are productive if fire frequency and intensity are stable, but tend to become degraded if fire occurs too frequently or is combined with other disturbance factors. Most fires are ignited by humans through carelessness, but may be started purposely to improve grazing or help with hunting. Most pines will not regenerate if fire occurs annually, so it is necessary to reduce the fire frequency. Total fire exclusion usually results in broad-leaved species reclaiming the site (Goldammer and Penafiel 1990).

Forest Fire History

The Ancient Fires

Even though fire has been an integral part of tropical forest ecology in the Asian and Pacific region and wild forest fires have occurred in the region for centuries, they were much less prevalent in the tropical rain forests compared to the dry forests, savannahs, and grasslands.

The wildfires that have been a feature of Southeast Asia's ecology since the Pleistocene Age are made possible by periods of reduced rainfall, long enough for even rain forests to become dry enough to burn. During the Ice Age, extended periods of minimal rainfall occurred in Southeast Asia, making large areas of the region vulnerable to fire. More recently, the recurring *El Niño* phenomenon has created conditions that enable large-scale wildfires to reoccur in the ASEAN region (Qadri and Scarsborough 1998).

Scientific evidence based on dating charcoal deposits found in the soils of East Kalimantan indicates that forest fires have repeatedly burned areas of lowland rain forest since about 15500 BC. Goldammer and Siebert (1989, 1990) report that the radiocarbon dates of soil charcoal recovered in their study areas in East Kalimantan indicate that forest fires occurred between about 15510 BC and 1650 AD. They also report that the thermoluminescence analysis of burned clay collected on top of an extinguished coal seam near active coal fires has proven fires occurred between 11200 and 13300 BC. Charcoal residues suggesting ancient forest fires were also found in several places in Brunei Darussalam and Sabah.

Humans probably had a role in starting forest fires in recent millennia, and may have deliberately burned forests to improve hunting for thousands of years. As prehistoric human settlers of the Indonesian archipelago began to switch from hunting and gathering to growing crops, they used fire to clear agricultural plots in the forest. The cycle of forest clearing, cultivation, and abandonment is known as swidden, kaingin, or shifting cultivation, an agricultural system adopted throughout most of the region over a period of thousands of years. Swidden cultivation has continued into this century in locations where soils are too poor to support permanent cultivation of annual crops. Until recently, swidden agriculture was the dominant form of cultivation in Kalimantan, and is still practiced there as well as in Sumatra. Typically, swidden plots are cultivated for one to three years, then abandoned to allow natural vegetation to regrow, creating a mosaic of pioneer and secondary vegetation patches in the mature forest. In areas with growing populations of forest dwellers, the number of years between abandonment and the next clearance of a swidden plot has been shortened to a period that does not permit regeneration to progress beyond pioneer vegetation.

Recorded Fires of the Past

In the absence of droughts, undisturbed mature rain forest is resistant to burning due to high humidity below the forest canopy. There is also a scarcity of fuel such as ground vegetation, leaf litter, and fallen branches due to the rapid recycling of fallen vegetative material. Forests adapted to grow on sand and limestone-derived soils are more susceptible to fire than those growing on other soil types, and peat swamp forests are particularly vulnerable to above and below ground fires when water levels fall during droughts (Whitmore 1984). Tropical rain forests recover even after a severe fire, if left undisturbed and if seed sources are nearby. But hundreds of years may be required to reach a successional stage[8] that approximates the species composition that existed prior to the fire. High intensity fire, followed by frequent burning, leads to conversion of tropical rain forest to grasslands, unlike monsoon forest formations in seasonally dry areas that recover quickly from frequent fires.

The majority of forests on the islands of Borneo and Sumatra have been affected by human actions, and tens of millions of hectares have been converted to grasslands and various agricultural uses. An analysis of remote sensing data from the mid-1980s indicated that the Indonesian archipelago contained about 10 million ha of grasslands at that time (RePPProT 1990). Much of the remaining forest has been logged in recent years, and logged forests are frequently degraded or converted to agriculture. The present landscape is a mosaic of vegetation types and land uses, including some intact forest ecosystems, logged forests in various stages of regeneration, scrubland, grassland, annual crops, and tree plantations.

Forest fires have been reported a number of times over the past 150 years on the island of Borneo, and such fires probably also occurred in Sumatra. Records of forest fires were first made in the late 19th century when Michielsen (in 1882) conducted a survey of the region between the Kalanaman and Cempaka Rivers (now Sampit and Katingan Rivers) in Central Kalimantan. He reported that forest fires had damaged a number of sites in 1877. Soon after, Gerlach recorded evidence of forest fires in what is now the Sentarum Lake Wildlife Reserve in the southwestern region of West Kalimantan (Meijaarad and Dennis 1997). It can no longer be assumed that tropical forest fires are a recent phenomenon. But the frequency and intensity of tropical forest fires have increased in parallel with the frequency and intensity of human activities in the forests (Schindele et al. 1989).

Grasslands still cover the 80,000 ha Sook Plains in Sabah as the result of a drought-related forest fire in 1915 (Whitmore 1998a). Periodic fires have been reported in the Danau Sentarum Wildfire Reserve in West Kalimantan since the middle of the 19th century. Brunig (1971) reports that the relatively fire-prone *kerangas* or heath forests of Sabah and Sarawak burned spontaneously or by human action in the 1880s, the early 1930s, and the late 1950s. So while the burning of forests of Sumatra and Kalimantan is clearly not a recent or geographically unique phenomenon, the fact that these islands remained largely forested until recent decades indicates that neither naturally caused fire nor human use of fire led to significant deforestation in the past.

Earlier fires were undoubtedly smaller in area and probably more spread out over time than the fires of the past two decades. A 1924 forest map of what are now the provinces of Central, East, and South Kalimantan showed that this large portion of Borneo was still 94 percent forest covered at the time (RePPProT 1990).

Earlier fires were undoubtedly smaller in area and probably more spread out over time than the fires of the past two decades

Fires in Recent Years

While the fires of 1997-1998 were severe, they were not the first such examples. Records in the region have shown that there have been at least nine instances of widespread fire and smoke in the region since the 1970s, occurring mostly during *El Niño* periods.

Indonesia

Areas in Indonesia that are prone to fire include forest areas whose canopies have been broken and opened, secondary forests, deciduous forests (particularly teak forests), and grasslands. Such areas are found in almost all provinces of Indonesia.

With the stepping up of economic activities in Indonesia's outer islands, forest fires have become commonplace, occurring every year. During pronounced *El Niño* years, when conditions are usually dry, fire and smoke problems tend to be much more serious. Serious fires occurred in 1982-1983, 1987, 1991-1992, 1994-1995, and 1997-1998. Less serious fires occurred in 1999. Again fires have been reported in March 2000, particularly from the Riau province. Media reports indicated that some 1,200 fires have been detected in Kalimantan and Sumatra. The economic cost of the fires has extended far beyond the destruction of large tracts of forestland. In addition to the direct damage these fires have caused to human and animal populations living in the affected areas, the resulting smoke has directly imperiled human health and economic well-being in adjacent AMCs.

> With the stepping up of economic activities in Indonesia's outer islands, forest fires have become commonplace, occurring every year

Fires of 1982-1983

One of the most serious of the recent fires was in East Kalimantan during 1982-1983, demonstrating the greater vulnerability of disturbed forests to blazes. In that fire season, ENSO caused large-scale wildfires, which ran out of control from several land clearings and slash-and-burn sites as well as from logging areas, *alang alang,* and camping sites. It has been estimated that the overall land area of Kalimantan affected by fire exceed 5 million ha. In East Kalimantan alone, about 3.5 million ha were affected by drought and fire. Of this, some 1.4 million ha were logged-over forest, 800,000 ha primary rain forest, 750,000 ha secondary forest, and 550,000 ha peat swamp forest. The fires resulted in the loss of timber values of about $8.3 billion, and a total of timber and nontimber values plus rehabilitation costs of about $9.1 billion (Goldammer et al. 1996). Undisturbed primary forests were less affected by fire, compared to the moderately and heavily disturbed forests. Logged-over forests are highly sensitive to drought and easily combustible (Malingreau et al. 1985, BAPPENAS 1999).

Fires between 1983 and 1997

Land and forest fires that occurred during the extended dry periods in 1987 (66,000 ha), 1991 (500,000 ha), and 1994 (4.87 million ha) were distributed over some 25 provinces, including Maluku and Sulawesi. These fires were larger than during years with normal rainfall. The smoke emitted from the Indonesian archipelago during these years was not primarily caused by forest fires alone, but also by the application of fire for converting forests into estate tree crops and forest plantations, as well as by slash-and-burn agriculture (Goldammer 1998b). Also, the burning of coal seams represents a permanent fire source from which wildfires spread whenever severe droughts occur and fuel conditions are suitable for carrying a fire.

Fires of 1997-1998 and Beyond

Noted by UNEP as one of the biggest environmental shocks since 1950, the 1997-1998 forest fires of Indonesia were among the most damaging in recorded history (UNEP 1999). The area affected by fire has been estimated as 9.76 million ha. Indonesia (and

Malaysia) experienced one of the worst recorded droughts in recent history during that period. It occurred in two spells. The dry conditions that started around April 1997 abated briefly by November 1997. But the *El Niño* persisted and drought resumed in early 1998, in a pattern reminiscent of the *El Niño* drought and fires of 1982-1983. The second spell lasted from January to May 1998, until the onset of rain.[9]

Less serious, sporadic fires occurred in the dry season of 1999. With the shock of 1997-1998 fires still strongly evident, the smaller outbreaks of 1999 did not attract much attention.

Two aspects of the fires that have affected Southeast Asia during the past two decades differentiate them from previous occurrences. First, the magnitude of the fires themselves surpassed all previous outbreaks of this type on record. Previous fires were much smaller, primarily because the scale of land clearances in the past was limited and consequently the fuel load for burning was also less. Second, the scale of the damage caused by transboundary haze pollution resulting from the fires has been without precedent.

The fires of the 1980s and 1990s were triggered by open burning for large-scale land preparation for commercial crops. This accounts for the exceptional magnitude of the fires themselves, and for the scale of the damage from the transboundary haze produced. All of the above factors have prompted much more swift responses from the AMC governments compared to their pre-1980 stance, that rains would eventually quell the fires, and at least in the long term, reverse any damage they may have caused.

Other ASEAN Countries

Even though the major centers of fires and haze during the last 20 years have been in Indonesia, other AMCs have also experienced forest fires, although on a smaller scale. Information available on the fire situation in these countries is scanty.

Some AMCs, apart from Indonesia, might experience significant forest fires and haze if conditions are created by land clearing for export-oriented commercial crops, socioeconomic evolution, and/or climatic variations.

Malaysia

The threat of forest fires in peninsular Malaysia has been relatively small and most of the recorded examples relate to plantation forests. Besides the documented fires in forest plantations, those in natural forests occur sporadically throughout the peninsula during dry spells of January-March and June-August. Such occurrences have been small in size and readily brought under control.

Fire appears to be a more serious problem in Sabah. The worst fires of recent years occurred in 1982-1983 when about 1 million ha of (mostly logged-over) forests were reported burned (Phillips 1987). The cause was attributed to a severe drought, which was also blamed in large part for the fires in Kalimantan during the same period.

In Sarawak, fires have been reported and documented to be confined to forest plantation areas, and to date have been relatively small (Mhd Saad et al. 1996). During 1997-1998, extensive fires did break out in Sabah, and to a lesser degree in Sarawak and in the peat and hill forests. Neighboring Brunei Darussalam also suffered small fires during the same period, extending over an area of about 6,500 ha of heath forests, peat swamp forests, and bushlands.

Thus, even though on a lower scale, forest fires in Malaysia remain a cause for concern, particularly since the country shares similar

The scale of the damage caused by transboundary haze pollution resulting from the fires has been without precedent

geographic, climatic, ecological, and land-use attributes with Indonesia.

Malaysia has a reasonably effective legal and institutional framework to control fires and haze, including: a system of fire permits and restrictions on open fires, a system for monitoring air pollution, forest management prescriptions in line with sustainability criteria, and a relatively advanced firefighting capability.

The Ministry of Science, Technology, and Environment has formulated a National Contingency Plan to Combat Forest and Plantation Fires in Malaysia. The Plan is executed by a National Forest and Plantation Fire Committee that is composed of various government agencies, with the mandate to develop guidelines and procedures to coordinate interagency fire response. The Fire and Rescue Services Department is the lead agency for fire suppression.

Malaysia has a reasonably effective legal and institutional framework to control fires and haze

Malaysia has pioneered the use of zero-burning techniques for forest clearance (Hashim et al. 1993) and is using persuasion, technical advice, and penalties to encourage plantation firms to adopt these techniques. Shifting cultivators in Sarawak are required to undertake prescribed burning to avoid wildfires. Many plantation units have their own fire detection and suppression systems. As part of routine forest management and as prescribed in the working plans, Malaysia maintains a system of firebreaks, and an adequate amount of firefighting equipment (BAPPENAS/JICA/ITTO 1999).

Philippines

As in the case of Indonesia, tropical rain forest is the dominant natural vegetation formation in the Philippines, but deforestation has progressed to the point that little intact lowland forest remains. Forest cover has diminished from more than half of the nation's land area in 1950 to 21 percent today. Population growth, commercial logging, and agricultural expansion are the main causes of deforestation. All fires are caused by human activity and often start from shifting cultivation. Meanwhile, fire preparedness planning and implementation has been more reactive than proactive (Castillo 1998). Forest fires occur in pure pine stands (*Pinus kesiya*) in the highlands of Northern Luzon, in broad-leaved forests adjoining shifting cultivation fields, and in grasslands (thereby complicating attempts at reforestation). The archipelago's 6 million ha of fire climax grassland are typically burned annually to enhance grazing. The pine forests are fire-prone and the broad-leaved forests are susceptible to burning during ENSO-related droughts. (Schweithelm 1998a). Laws forbidding swiddening and forest burning have been largely ineffective, resulting in a paradigm shift in the late 1980s toward community-based forest management.

The Philippines seems to have suffered from the second worst fires in 1982 and 1983 (after Indonesia). The total burned area was estimated at 8,063 ha in 1982 and 117,951 ha in 1983. In the years between 1984 and 1989, fires burned between 3,000 ha and 37,000 ha of forests per year. In the years 1990, 1992, and 1993, fires affected 12,473 ha, 36,906 ha, and 14,914 ha, respectively.

During 1997-1998, fires occurred in several provinces including Benguet, Bukidnon, Davao Oriental, Mountain Province, Negros Occidental, Nueva Vizcaya, Palawan, and Pangasinan. The fires consumed almost 50,000 ha of natural and plantation forests and 37,500 ha of grasslands.

Thailand

The forests of Thailand are categorized into two main groups: evergreen forests (45 percent) and deciduous forests (55 percent). Deciduous forests are further classified into three main subgroups: mixed deciduous forest, dry dipterocarp forest, and savannah. Since they shed their leaves during the dry season of December to April, creating high fuel loads, these forests are highly vulnerable to fire.

About 90 percent of the nation's land area was forested at the beginning of the 20th century but by 1999 this had reduced to about 23 percent, including areas under scrub and bamboo (FAO 1999a). The rapid rate of deforestation has been, and continues to be, the result of agricultural expansion to accommodate the growing human population, which has increased 10-fold since the beginning of the 20th century. Teak was always the main focus of commercial forestry, but output has fallen as deforestation has increased, leading to Thailand becoming a net timber importer in 1977. A total nationwide harvesting ban in natural forests has been imposed since 1989 (Mhd. Saad et al. 1996).

Fires occur annually in the dry season from December to May, typically in the form of ground fires in the drier forest formations, grasslands, and dryland agricultural areas, and mostly in the north and northeastern parts of the country.

Virtually all fires are started by humans in order to facilitate gathering of NWFPs, dispose of agricultural waste, convert forestland into agricultural fields, settle conflicts, help with hunting, and also due to carelessness. People have generally believed that fire is not harmful to forests.

Fire data are not regularly collected for the entire country, but an aerial survey in 1984-1986 indicated that 3.1 million ha of all vegetation types are burned annually, while a repeat survey in 1992 showed that the burned area was down to 2 million ha.

The National Forest Policy (1985) mandates that a plan for slowing deforestation must include forest fire prevention and suppression. Other laws set penalties for igniting open, unauthorized fires. Attempts at fire management began in 1971 with short-term technical assistance through a consultant, funded by the Canadian Government. This led to the training of some Thai forest officers abroad in forest fire control in the early 1970s and the establishment of a Forest Fire Control Section in the Forest Management Division of the Royal Forest Department (RFD). This section was upgraded to a Subdivision in 1981, and Office of Forest Fire Control and Rescue in 1991.

RFD has taken the following actions to prevent and control forest fires:

- established forest fire control units in fire-prone areas;
- cooperated with the Ministry of Interior to organize and train local government officials and volunteers in firefighting;
- organized a network of government agencies and commercial aviation firms to report fires;
- provided funds to purchase firefighting equipment;
- conducted a nationwide fire prevention campaign; and
- begun collecting fire data and conducting research.

RFD has had some success in reducing forest fires through public fire prevention campaigns and strengthening of local fire management brigades. Thailand is the first Southeast Asian country in which helicopters and fixed-wing aircraft have been used for aerial firefighting and personnel transport.

Further improvements in Thailand's equipment for fire management capability are constrained by budget and personnel limitations (Schweithelm 1998b).

Thailand is the first Southeast Asian country in which helicopters and fixed-wing aircraft have been used for aerial firefighting and personnel transport

Viet Nam

The forests of Viet Nam, accounting for about 28 percent of the country's land area, have been considerably degraded due to shifting cultivation, fuelwood collection, overfelling, and fires. The unsettled situation in the country for the past several decades has accelerated the environmental degradation. Viet Nam is now in the process of rebuilding its resource management systems and related institutions.

The main problem areas with regard to forest fires in Viet Nam are the seasonally flammable deciduous forests, indigenous pine forests, degraded natural vegetation, shifting agriculture and deforestation complex, and intensively treated agricultural lands. The peak of burning activities in Viet Nam is during the mid to late dry season (January-April).

One major problem is the fires occurring in the economically valuable *Melaleuca leucadendron* forests. Available fire information is limited. In the mountainous pine forests in the highlands of Da Lat, northeast of Ho Chi Minh City, the annual area reported destroyed by fire usually does not exceed 100 ha, but many fires seem to be unreported (Goldammer 1992).

Causes

To start a forest fire requires inflammable matter (fuel load), a source and reason leading to actual ignition, and a favorable condition where the ignited fuel can spread the combustion

To start a forest fire requires inflammable matter (fuel load), a source and reason leading to actual ignition, and a favorable condition where the ignited fuel can spread the combustion. Climatic conditions, fuel source, and its nature define the fire-proneness of a situation; whereas the ignition source and condition of burning define the fire itself.

In the ASEAN region, various factors have been associated with the considerably increased incidence and intensity of fires of late. These include: (i) careless logging that has killed trees unnecessarily, left too much wastewood in the forest, opened the closed canopy exposing the forest floor to drying by sunlight and wind, and made the forest accessible to agricultural settlers; (ii) increasing numbers of people clearing land for farming in or near forests by burning; (iii) temporary forest conversion using traditional slash-and-burn methods; (iv) permanent conversion of forestland to agricultural uses (e.g., cultivation of food crops, estate crops, horticultural products, grazing of livestock); (v) conversion of natural forest (mainly exploited or otherwise degraded secondary forest) for the establishment of industrial timber plantations; (vi) drainage of peat swamps for agricultural or other purposes; and (vii) fires that have spread and turned wild from these interventions.

While the causes of forest fires are more or less common to all the AMCs affected by the recent fires and haze, discussions tend to focus on Indonesia because of its significance to the region and the availability of information from several studies on its forest fires. These suggest that the main causes of fires and haze are: (i) the imperatives of national economic development and related financing needs; (ii) land conversion using open fires, prompted by private profit maximization; and (iii) problems relating to land tenure and social equity. These causes are aggravated by factors such as ENSO-induced drought; technological and infrastructural limitations; and institutional inadequacies.

Land Conversion and Preparation

It is a common misconception that most land conversion in the ASEAN region involves the clearing of pristine forest. While this may be true in the case of peat swamp forestland, much land conversion in the region simply continues the process of human intervention that began with timber extraction from virgin forestland. According to a recent report, of the total area of about 4.8 million ha consumed by fire during 1994, 88 percent comprised logged-over forests, some of which were under cultivation by traditional dryland agricultural techniques. By contrast, shifting cultivation areas accounted for only 5.3 percent, transmigration farmland 4.5 percent, areas occupied by previously-established plantations only 0.8 percent, and natural protected forests a scant 0.2 percent. The corresponding figures for 1997 (which exclude information for calendar year 1998) tell a similar story. Of the total land area consumed by large-scale fires during that year, logged-over production forests accounted for 62 percent. The remainder comprised the following: national parks, 20.6 percent; protection forests, 8.4 percent; nature reserves, 6.5 percent; and recreation parks, 0.6 percent (MOE/UNDP 1998).

Observations made during the fires and haze of 1997-1998 and previous cases have indicated that the intensity of fire in logged areas was directly related to the intensity of logging.[10] Even severe fires did not completely destroy moderately logged stands where, after the fire, a few trees with green foliage could still be observed, although spaced and scattered. In heavily logged forest areas, where remaining trees were widely spaced, shrubs had formed a thick ground cover, providing an efficient biomass source for the fires after the extensive drought. Here, the fuel consumption was more complete (BAPPENAS 1999).

The main factors causing increased combustibility are wasteful logging; and forest clearance for agricultural crops, estate crops, and forest plantations leading to buildup of dry materials. The changing composition of vegetation due to mono-cropping, draining of peat swamps, and mining practices that expose coal deposits also contribute to altering the fuel characteristics.

Thus, land clearance and preparation activities influence the volume and condition of the fuel load, serve as the ignition source, and often cause the spread of fire. These activities, in effect, take advantage of drought conditions created by weather disturbances such as ENSO.

Drought Conditions

Indonesia's climate is shaped by the annual cycle of east and west monsoons, which affect rainfall and winds across the archipelago. The major islands and most smaller island groups are dominated by a humid tropical climate and rain forest vegetation, although the Lesser Sunda Islands, eastern Java, and small parts of other islands have mild to pronounced rainfall seasons. Drought in Indonesia is generally experienced between May and October.

There are two weather phenomenon considered to be crucial to the spread of forest fires and haze. The first is recurrent ENSO conditions, bringing extraordinarily dry weather to the region (and in the process, creating conditions ideal for disposing of biomass residue by open burning). Prolonged drought in Indonesia occurs at least once every 10 years. Data on rainfall in Bali, Java, Kalimantan, Sulawesi, and Sumatra since the early 1900s show that prolonged drought occurred 17 times during the century, of which 11 corresponded with an *El Niño*. When the dry season in Indonesia occurs at the same time as an *El Niño*, the result is a prolonged drought, which extends from June to November and can continue until May of the following year. The second weather factor is that in geographic areas that lie close to the equator, there is relatively little wind. This means that in the ASEAN areas where land conversion is in progress, the weather forces that mix (and dilute) the particulate matter from land conversion fires with unpolluted air are weak.

The intensity of fire in logged areas was directly related to the intensity of logging

Compared with the previous *El Niño* years, the one in 1997 had the highest impact on drought and fires in Indonesia

In Indonesia, a prolonged drought as a consequence of an *El Niño* has occurred five times over the last 20 years. This had varying effects in different parts of the country, depending on the strength of the *El Niño* and the monsoon winds sweeping past Indonesia. Compared with the previous *El Niño* years, the one in 1997 had the highest impact on drought and fires in Indonesia. Forest and land fires in 1997 occurred in nearly all provinces.

Contributing Constraints

During the recent forest fires and haze, particularly in 1997-1998, several factors have aggravated the causes of fires.

Physiographic

The physical condition of the locality—difficult terrain, slope and accessibility, and inadequate availability of water—often makes fire management measures difficult to carry out. Fire crews often struggle to access forests in steep terrain and peatlands. Conditions such as low humidity, lack of clouds, and inaccessibility of natural water bodies affect fire suppression operations. Because of such constraints, performance of water bombing and cloud seeding operations in Indonesia during the 1997-1998 fires was unsatisfactory.

Sociocultural

Cultural and/or religious leanings of indigenous and rural communities, fire worship, and practice of slash-and-burn agriculture can become obstacles to adopting scientific fire management. Other sociocultural factors include land tenure issues, conflict of interest among different classes of people and communities, and use of fire as a weapon to inflict harm on the enemy. Such situations are common among indigenous communities and between the indigenous communities and transmigrants. Also, in some situations, rural people move into the forest to eke out a livelihood by illegally clearing and cultivating forestland.

Inadequate social awareness is, in several cases, reflected in eco-hostile and private profit-maximizing attitudes by private operators unwilling to invest in fire protection. Also, fire is often set deliberately for individual economic gain, through grazing, collection of honey, and other NWFPs, as well as hunting and gathering. In addition, villagers are also often reluctant to fight fire without attractive cash incentives.

Technological and Infrastructural

Technological constraints include lack of appropriate technology; inadequate knowledge and appreciation about technological possibilities as well as limitations; insufficient tools and equipment; inadequately trained personnel; lack of research support; inadequacies in forest fire management exemplified by lapses in monitoring, fire danger warning, fire protection measures, presuppression planning and preparedness, and firefighting; and reluctance to adopt zero-burn techniques of land preparation and low impact logging.

Lack of infrastructure such as access roads, fire corridors, fuelbreaks, observation towers, water reservoirs, communication and mapping facilities, satellite stations, etc., affect the efficiency of fire management.

For example, the total reported length of cleared fireline in Indonesia is only about 150 km, which appears grossly inadequate. Adequate infrastructure is found only in areas covered by some of the donor-funded projects.

Institutional

Most of the important constraints are institutional in nature. Lack of political will, inappropriate and poorly specified policies, weak legislation, ambiguous regulations, bureaucratic procedures, and inadequate resources for enforcement of laws and regulations have come up again and again as crucial and crippling constraints. Policy gaps and conflicts relating to land use, tenure security, and economic development add considerably to the forest fire danger.

Indonesia's economic policy, which allows for large-scale expansion of commercial crops, encourages land speculation and may lead to ecological disaster. The pace and manner of plantation development has been such that the Ministry of Forestry and Estate Crops (MOFEC) is little more than a hapless bystander (Anon 1997b). Unlike other countries in the region, Indonesia's policy on timber pricing subsidizes the concessionaire. In some other countries it is based on competitive bids. A study indicated that in 1990, Indonesia's timber subsidies cost the Government $2.5 billion in lost revenues (Constantino 1990); and this further leads to wasteful use of resources. For reasons related to tenure security, many forest dwelling communities do not yet acknowledge current forest boundaries.

An absence of properly designed plans relating to land use; inadequacies of forest management and fire management; and lack of updated land-use maps, fire maps, fire information management, and dissemination reflect institutional weaknesses. Lack of institutional ability to learn lessons from past mistakes and to follow up on recommendations is a matter to be addressed seriously. For example, there have been several recommendations to curtail the volume of timber production to ensure sustainable forest management (SFM) in Indonesia, including protection of forests from fire and other damaging agents. A national fire management plan was prepared by the Ministry of Forestry (predecessor of MOFEC) in the mid-1980s, in cooperation with FAO.

According to the plan, the forest area of the country was to be divided into firefighting control units of 40,000–50,000 ha in Java, and 100,000–150,000 ha outside Java, such that fires (even if they occur) can be prevented from spreading and confined to the control unit (GOI/FAO 1990b). But this plan has not been pursued. Again, after the Bandung Conference of 1992, a Long-Term Integrated Forest Fire Management Strategy for Indonesia was prepared, but this also was not seriously followed up.

Inadequate research, technology development, and knowledge about the different aspects and situations of fire (for example: in coal seams and peat swamps); and inadequacies of measures and means at all levels to improve fire management skills have been major constraints. There are relatively few personnel trained in fire science.

Recently, efforts have been made in Indonesia to strengthen training facilities. A report indicates that by the end of August 1998 there were 16,175 persons trained in fire protection and suppression, up from about 14,000 in 1997 (MOFEC 1998).

Some of the other constraints identified by analysts following the 1997-1998 fires and haze, particularly as applied to Indonesia, include the following.

- Increasing vulnerability of forestlands to fires resulting from unsustainable forest management and harvesting practices.
- Conflicting and inadequately identified roles and responsibilities of institutions concerned with managing forestlands and forest fires, especially with regard to mandate, authority, financial resources, and accountability.

Indonesia's economic policy, which allows for large-scale expansion of commercial crops, encourages land speculation and may lead to ecological disaster

The three biggest fires were those of 1982-1983, 1994, and 1997-1998, and the areas affected, respectively, were 5,000,000 ha; 4,865,000 ha, and 9,756,000 ha in Indonesia

- "Business as usual" attitude of government agencies.
- Indifference to the cyclical nature of fire and haze from institutions charged with managing forestlands and forest fires, including disregard for early warning announcements concerning the onset of ENSOs.
- Inadequate information and systems for communicating fire-related information.
- Vested interests that marginalize issues relating to fire and haze as a means of favoring a particular sector, corporate body, or individual(s).
- Neglect by government and entrepreneurs to local customary rights, livelihood strategies, and traditions, which result in erosion of customary law, social cohesiveness among indigenous groups, and traditional knowledge relating to the prevention and control of fires.
- Lack of incentives for promoting logging techniques that lead to sustainable output of production forests and mechanical land clearing; inadequate use of logging residues as productive inputs and development of products made from them; and absence of an incentive system to involve local people.
- Insufficiency or nonexistence of committed funding at national, subregional, provincial, and local levels to adequately address the issue of forest and land fires.[11]
- Lack of a proactive quick action approach.[12]
- Delay or inaction, often due to lack of funds, in rehabilitating the badly burned areas. Apart from harboring pests and diseases, the dead and charred materials remaining in the area can cause future fires by providing a highly combustible fuel load.
- Poor coordination of fire management (including fire suppression). Inadequate coordination among sectors, between central and provincial levels and/or among the donors has been reported.[13]

The Dimensions of the Impact

Area Affected

The size of the area affected by fires over the years has varied considerably. The three biggest fires were those of 1982-1983, 1994, and 1997-1998, and the areas affected, respectively, were 5,000,000 ha; 4,865,000 ha, and 9,756,000 ha in Indonesia. Distribution of the fires differs depending on the interpretational and definitional differences, and also on how the estimates were made.

1994 Fires

In 1994, fires (of varying intensities) occurred in 24 provinces of Indonesia. Distribution by land-use type is given in Table 2.

Table 2 suggests that the incidence of fire in primary forests is relatively low (8,000 ha), far less, for example, than the extent of fire in reforestation areas. Based on this data, fires appear to be closely associated with other land-use activities and hence fire control should not be the sole responsibility of MOFEC (MOE-UNDP 1998).

1997–1998 Fires

The 1997-1998 fires occurred in 27 provinces of Indonesia, falling within the five large islands. Nearly 70 percent of the fires were in Kalimantan. Irian Jaya, Sulawesi, and Sumatra were also significantly affected (BAPPENAS 1999). Fires also occurred on a smaller scale in Brunei Darussalam, Malaysia, Philippines, and Thailand. Details of their impacts are not available.

TABLE 2 Spatial Distribution of Areas Affected by 1994 Fires in Indonesia

Land-Use Type Affected by Fire	Area Burned ('000 ha)
Traditional Dry Land Farming	2,800
Shifting Cultivation	1,500
Transmigration Farming	260
Plantations	221
Transmigrant Settlements	39.5
Reforestation Areas	20.5
Timber Estates	17
Natural Forests	8
Total	**4,866**

Source: Goldammer 1997.

TABLE 3 Spatial Distribution of Areas Affected by 1997–1998 Fires in Indonesia

Land-Use Type Affected by Fire	Area Burned ('000 ha)
Agriculture	3,843
Estate Crops	119
Timber Plantations	188
Lowland Forest	3,100
Peat and Swamp Forest	1,450
Dry Scrub and Grass	700
Montane Forest	100
Total	**9,500**

Source: ADTA INO 2999: *Planning for Fire Prevention and Drought Management* (BAPPENAS 1999).

ADB under its advisory technical assistance[14] (ADTA) used a variety of techniques, depending on availability of data, to obtain spatial estimates. For estimates of the area burned in Irian Jaya, a combination of aerial and ground surveys was used; along with a comparison of Total Ozone Mapping Spectrometer (TOMS) imagery for Irian Jaya, Kalimantan, and Sumatra. The rest of the estimates were obtained from analysis of SPOT images by the Center for Remote Imaging, Sensing and Processing (CRISP) at the National University of Singapore.

In addition to computation of the area burned, CRISP (Liew et al. 1998) undertook a manual classification of fire scars for both Kalimantan and Sumatra, concluding that about half of the affected area consisted of plantations and/or agricultural lands, 20 percent was peat swamp forests, and the remainder secondary forests and bushes. CRISP has also performed preliminary estimates of areas burned in Java and Sulawesi through a visual assessment of SPOT Quicklook Mosaics. In the absence of detailed analyses of satellite imagery for all the affected provinces, a lack of up-to-date landcover maps, and ability to overlay all fire areas on land-use or land classification systems, assessments of fire location by functional land-use categories were achieved by extrapolation of findings by CRISP. Distribution by land-use type so assessed is given in Table 3.

The extent of the forest area burned and the share of peat and swamp forest in it are particularly noteworthy, because of the transboundary implications (see Box 7).

Transboundary Haze Pollution

The transboundary dimension of fires can manifest itself in various ways: fires crossing national boundaries cause direct damage, mass migration of wildlife (and also of humans)

BOX 7 Tropical Peatlands

Peat forests are waterlogged forests growing on a layer of dead leaves and plant material of up to 20 meters deep. These are a biologically diverse resource and a recognized component of the world's biological heritage.

The countries of Southeast Asia, in particular Indonesia and Malaysia, have more than 20 million ha, or 60 percent, of the world's tropical peatlands. In the event of a prolonged spell without rain, and a lowering of the water table in the peatswamp, the organic layers progressively dry out. Subsequent fires have spread to forests covering thousands of hectares of peatlands. Fires in these peatlands create much more smoke per hectare than other types of forest fires and are difficult to extinguish. The fires go deep underground and can burn uncontrolled and unseen in the peat deposits for several months.

While the spread of surface and ground fires in this type of organic terrain may not be severe, deep burning of organic matter leads to the toppling of trees and a complete removal of standing biomass. Further, the smoldering organic fires may persist and be reactivated as an ignition source in the next dry spell (Goldammer and Seibert 1989).

In the past 20 years, the incidence of major fires in the peatswamp forests of Southeast Asia has been increasing. In East Kalimantan, a fire that started in September 1982 lasted for 10 months and affected more than 35,000 ha. The fire followed an almost unprecedented period of drought in the region, associated with an *El Niño*.

The contribution of tropical peatlands to the global carbon cycle is higher than in most temperate zones. It is estimated that 15 percent of the global peatland carbon resides in tropical peatlands. Peatswamp fire emission contains, like other biomass-burning emissions, large amounts of carbon dioxide, carbon monoxide, particulate matter, oxides of nitrogen and sulfur, and a variety of volatile and semivolatile compounds. However, peat vegetation has a higher biomass density and burns predominantly under smoldering combustion. This results in higher emissions of all pollutants per hectare burned.

At the annual meeting of the standing committee of the Convention on Wetlands, better known as the Ramsar Convention, 27 countries and four global NGOs gathered in Switzerland on 2 October 1997. They expressed their concern at the forest fires in Indonesia. Louise Lakos, chairperson of the committee, noted: "The members of this international conservation body drew attention to the fact that a large proportion of the area burning is peatswamp forest, which constitutes an important global wetland type, which we cannot afford to lose. Time is short and action is needed urgently."

Source: *Down to Earth*, Vol. 6 No. 11, 31 October 1997.

The haze-affected countries have borne much of the cost of the region's recent fires, though they have had little control over their magnitude, frequency, or duration

across borders, impact on water quality and fish resources in international waters, and—most important—transboundary atmospheric pollution and other haze effects. This last mentioned impact was highly evident in the wake of the 1997-1998 fires in the ASEAN region. As Ramon and Wall (1998) observed, "whereas the impact of fires concerns mainly foresters and conservationists, it is the smoke that causes politicians and economists to react."

Fires cause smoke, the smoke mixes with the atmosphere and drifts around, causing transboundary atmospheric pollution and related problems. The haze-affected countries have borne much of the cost of the region's recent fires, though they have had little control over their magnitude, frequency, or duration. Emissions from wildfires are thus a regional problem, even though the fires themselves may occur well within the national boundaries of individual AMCs.

Haze Formation and Dispersion

Forest fires and other vegetation fires produce gaseous and particle emissions that have impacts on the composition and functioning of the global atmosphere (Crutzen and Goldammer 1993; Levine 1991, 1996; Van Wilgen et al. 1997). These emissions interact with those from fossil-fuel burning and other technological sources, which are the major cause of atmospheric pollution and human-caused climate changes.

Open burning to dispose of biomass residue of land conversion involves stacking it into large heaps and leaving it undisturbed until it is dry enough to burn. It is then set alight. The result is typically a low-temperature fire that only partially burns the material to be disposed of. A relatively large quantity of partially-combusted material therefore remains, much of it being light enough to be carried into the air by the heat generated by fire. A similar process also happens when wildfire enters a forest.

Once released into the atmosphere, the partially-combusted material tends to remain stationary, unless there is sufficient wind to mix it with fresh air free of particulate matter. If enough mixing takes place, the partially-combusted material from the fires becomes so dispersed that it is relatively benign, and for the most part, unnoticeable. This is ordinarily the case in ASEAN countries where land conversion is in progress. In these areas, land-clearing fires occur continuously, on a year-round basis, and often the production of emission materials and local formation of haze remains unnoticed.

However, when a large enough number of land-clearing fires occurs at the same time in a limited area, or when the fires in a particular area reach a large enough scale, so much emission material is released at the same time that the atmosphere is incapable of fully diluting it. If the resulting buildup of atmospheric debris becomes sufficiently concentrated, winds ultimately transport the cloud of haze into the airspace of recipient countries before it can be adequately diluted. Transboundary haze is born.

Therefore, haze pollution can be said to be "transboundary" only if its density and extent is so great at source that it remains at measurable levels after crossing into another country's air space. Reducing transboundary haze pollution in the region, therefore, ultimately requires limiting the amount of emissions from open burning that each member country allows to enter the atmosphere during any particular time. The aim of limiting the emissions (and their release into the atmosphere) should be to control pollution both within boundaries and at a transboundary level.

Most particle processes in the atmosphere, such as atmospheric deposition rate and residence time, light scattering properties and visibility, deposition pattern within the human lungs, and health impacts depend on particle size.[15] While coarse particles flush out of the atmosphere within several hours up to a day, fine particles have the longest residence time (up to weeks) in the atmosphere and travel extensive distances (hundreds to thousands of kilometers). Their elimination out of the atmosphere is mainly due to rain.

Factors Affecting Haze Dispersion

The haze problem suffered by Indonesia and its neighbors, due to the 1997-1998 wildfires, was a result of a combination of factors—the volume of smoke, humidity, and the level of wind speed and rain.

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The distribution of haze away from the biomass fires in Indonesia is primarily controlled by wind and vertical mixing. The most significant large-scale influence on winds in the region is the position of the intertropical convergence zone (ITCZ), which exerts control over the broad-scale wind speed and direction.

By September 1997 many large and uncontrolled fires were burning in the peat areas of East-Central Sumatra, much of South Sumatra, and Central and West Kalimantan. During the September-October period, thick haze blanketed these regions in particular. In late September-early October the haze was carried out of these regions, particularly to the north and west under the influence of relatively strong trade wind flow. It was during this time that peninsular Malaysia and Singapore were especially hit by haze. This was a period during which the ITCZ was lying well north over the Mekong area countries and the Philippines, with the trade winds to the south of the ITCZ having a strong north-south component. As the ITCZ moved south later in October, the airflow developed more of an east-west component, Haze from fires in peatland is estimated to contribute 60 percent and converted forests 18 percent of the total smoke and haze produced

pushing most of the haze away from the fire zones, toward the west and into the Indian Ocean.

The fires of February-April 1998 were largely confined to Borneo, and in particular to East Kalimantan province. Haze became thick again during March and April 1998, but was largely confined to Borneo, especially in the south. The presence of a broad area of low-level convergence over Borneo at this time resulted in light low-level winds (or lack of strong winds), which limited the haze movement off the island.

Magnitude of Dispersion

Fires do not respect national (in some cases, even natural) boundaries. During the 1982-1983 East Kalimantan fires, the haze also reached as far as peninsular Malaysia and Singapore, lasting an entire month and covered an area of about 35 million ha. In 1997, haze covered about 100 million ha of land and water and lasted as long as six months. From September to November 1997, the dense haze from the Indonesian fires spread over an area the size of Western Europe, affecting some 70 million people in the region, directly or indirectly. This haze was, probably, the worst on record. The 1998 fires in Indonesia did not affect mainland Asia as much as in 1997. The haze covered the source area of East Kalimantan and spread over to West Kalimantan, southeastern Sarawak, and parts of peninsular Malaysia.

Critical Sources of Haze

Haze from fires in peatland is estimated to contribute 60 percent and converted forests 18 percent of the total smoke and haze produced. Instead of stray individual fires, 80 percent of the haze was produced by seven clusters of fires in and around peat forests in Kalimantan and Sumatra. Shifting cultivation accounted for only 1.5 percent of the haze. The thickest haze came from an extensive fire in a 1 million ha area of peat being drained by the Government for a massive rice planting project, known as the Grand Million Hectare Peatland Project *(Projek Sejuta Hectare Lahan Gambut)*. During the 1997-1998 fires, more than 700 million mt of carbon dioxide were released into the atmosphere from the burning of the peat[16] (Levine 1998).

Adverse Impacts of Haze

Air Pollution

At the peak of the haze, the Air Pollution Index (API) reached unprecedented levels in the region. An API count exceeding 100 but below 200 is considered unhealthy; between 200 and 300 is very unhealthy; and between 300 and 500 is considered hazardous. API readings remained in the hazardous range for long periods in September and October 1997 in Sarawak, with a high of 849 recorded. A reading of 1,000 was recorded in the interior of East Kalimantan in mid-April 1998, a level that is probably not unusual in areas close to the fires. Malaysians and Singaporeans were informed when air pollution reached unsafe levels, and were warned to take appropriate protective measures.

In Miri, as the API continued to hover above the 500 mark in April 1998, the Sarawak Natural Disaster Relief Committee declared a host of emergency mitigation measures, including closing of schools and kindergartens, advising residents to wear protective masks and to refrain from using private motor vehicles, and advising polluting industries (mainly in the quarry, mining, cement-mixing, asphalt, saw-milling, and transport sectors) to scale down operations in order to reduce the volume of pollutants being emitted into the atmosphere (Abraham 1998).

Most Indonesians were, however, unaware of the level of health hazard they faced. Some areas were affected by the haze from July to December 1997, and it started again in February 1998. Exposure to acute air pollution elevates the probability of premature death in vulnerable groups such as asthmatics, people with chronic lung or heart disease, and young and old pneumonia patients.

Health Hazards

According to the Economic and Environment Program in Southeast Asia (EEP-SEA) and WWF (1998 b, c), the haze of 1997 cost the people of Southeast Asia some $1.4 billion, mostly in short-term health costs. More than 40,000 persons were hospitalized for respiratory and other haze-related ailments. The long-term impacts on health of exposed children and elderly are as yet unknown. In Kuching, Sarawak, Malaysia, at one stage, the Government came within a hairsbreadth of evacuating the city's 400,000 inhabitants. In Indonesia alone, health officials estimated that 20 million people suffered from health problems related to the haze.

Impairment of Visibility

The effect of haze on light and visibility has an impact on economic production (manufacturing and agricultural), transport, tourism, etc., while haze-caused accidents result

BOX 8 Air Pollution and Health Effects

Air Pollutant Standard Index (PSI)	Health Category	Health Effects	Preventive Measures
Up to 50	Good	None	None
51–100	Moderate	None or limited for the general population	Not necessary
101–199	Unhealthy	Moderate symptoms for sensitive individuals, followed by irritation in healthy population	Individuals with light heart and respiratory problems have to reduce physical movement and outdoor activities
200–299	Very unhealthy	Significant symptoms as well as drop in tolerated body movement or exercise in heart and lung patients; general symptoms among healthy population	Aged and sick individuals have to stay indoors and reduce physical exercise; the public has to avoid excessive outdoor activity
300–higher	Hazardous	Appearance of certain early diseases in addition to clear and significant problems as well as decrease in tolerated body movement or exercise for healthy population; index of more than 400 could potentially cause premature death for sick people and the aged if not treated properly; healthy individuals will have symptoms that restrict normal activity	Aged and sick individuals have to stay indoors and avoid physical activity; at Index levels of more than 400, people have to avoid physical outdoor activities; everybody has to stay indoors, close all windows and doors, and limit physical activity

Source: World Health Organization.

The 1997 haze was so thick at times that visibility was reduced to less than 10 m, making land, sea, and air travel hazardous

in loss of lives. Several gaseous compounds in the haze are likely to affect global environment and climate. Quantitative evaluation of impacts was, however, limited due to the fragmentary particle measurement data and methodological problems.

Particulate matter scatters the light and causes severe reduction of visibility. Analysis of freshly emitted biomass burning particles generally have two size distributions, consisting of fine particles smaller than 2.5 microns in diameter ($PM_{2.5}$) and coarse particles ranging from more than 2.5 microns diameter to about 10 microns (PM_{10}). In biomass emissions, the fine particles represent up to 90 percent of the total mass of particles emitted (Ward 1998). The size distributions of partially aged biomass burning particles found in Indonesia, Malaysia, and Singapore indicate that the ratio of $PM_{2.5}$ to PM_{10} is about 80 percent. This ratio includes the urban particle background, whose fine particle fraction generally contributes about 50 percent of PM_{10}. These results indicate that the fine particle fraction in haze conditions is much higher than in urban background aerosols (Dieterle and Heil 1998).

During the 1994 fires, haze pollution in Sumatra reduced the average daily minimum horizontal visibility to less than 2 km. At the end of September of that year, visibility in Singapore dropped to less than 500 meters (m), while in Malaysia it dropped to 1 km or less in some parts of the country. Haze disrupted land, sea, and air transportation.

The 1997 haze was so thick at times that visibility was reduced to less than 10 m, making land, sea, and air travel hazardous (see Box 9). In some areas, visibility fell to only a few meters for several months. In one Indonesian town, school children were reported to have been tied to a rope to prevent them from becoming lost in the haze on their way to school. On 11 April 1998 the Sultan of Brunei's palace became almost invisible behind a thick curtain of haze (Associated Press, 11 April 1998), as were Kuala Lumpur's tallest-in-the-world twin towers in September and October 1997, and again in April 1998.

Disruption to Transport

Transport was also severely disrupted. Closures of airports and cancellations of flights were common in the region. River transport in Borneo and marine traffic in the Strait of Malacca were also disrupted. Economic losses from such disruptions, and aircraft and maritime accidents were compounded by steep declines in tourist arrivals.

Similar problems have been recorded during virtually every major outbreak of fires and haze in the region since 1982-1983. Following each of these instances, several AMCs have resolved

BOX 9 The Toll of Haze

The smog arising out of the 1997 fires spread to Brunei Darussalam, Indonesia, Malaysia, Philippines, Singapore, and Thailand, affecting a population of 70 million.

- On September 26, all 234 people on board a jetliner died when it crashed before landing in northwest Indonesia. Visibility was poor due to the haze.
- An Indian cargo ship collided with a Panamanian vessel in the Strait of Malacca, killing 29 people. Reason: poor visibility.
- Seven boat accidents were reported in Kalimantan's Mahakam River. In one, nine students were killed.

Doctors point out that the smog (haze) can cause a range of ailments from heart and lung diseases to damage to the nervous system, blood, and kidneys.

Experts predict that the impact of the forest fires in Indonesia is potentially more dangerous than that of the oil fires in Kuwait during the 1990 Gulf War.

Source: *Down to Earth*, 31 October 1997.

to prevent any recurrence. But despite such resolve, disasters due to fires and haze have occurred repeatedly in the AMCs.

Global Warming

Most of the gases present in haze play direct or indirect roles in regulating the atmosphere of the earth (Wirawan 1993). Their release during large-scale burning leads to an increase in the concentration of greenhouse gases, thereby contributing to global warming. Burning peat is especially detrimental because it releases carbon into the atmosphere that has been in storage for thousands of years, and smoke from peat fires contain high levels of sulfur oxides (see Box 7). British peat specialist Jack Rieley estimated that the peat fires in Indonesia in 1997-1998 could have released more carbon dioxide than the annual contribution from cars and power stations in western Europe (WWF 1997). Efforts are continuing to quantify the amount of biomass that was burned in the 1997 fires, in order to estimate the amount of carbon dioxide released from the burning of above-ground vegetation (Liew et al. 1998, Ramon and Wall 1998). The haze also has effects on the world's climate (see Box 10).

Ozone Concentration

Nitrogen oxides in haze can be quickly converted into nitric acid, causing acid rain. (Rain falling in Sabah in 1997 was highly acidic, registering pH3.85, a level of acidity that damages plants and aquatic life.) Haze can also undergo a photochemical reaction that greatly increases the ground level concentration of ozone (Abraham 1998, Crutzen and Andreae 1990). Ozone causes eye irritation, impairs lung function in humans, and reduces crop production by damaging plants (Wirawan 1993).

Economic Costs

Economic costs of the fires were high and they had profound impacts. Some of them were highly visible. The fires burned villages, caused losses of property, and injury and harm to people. Many lost their means of livelihood. All those who lived in haze-affected areas suffered discomfort.

The fires burned villages, caused losses of property, and injury and harm to people. Many lost their means of livelihood

BOX 10 Effects of Haze on World's Climate

Scientists studying the effects of forest fires have, so far, focused on the cooling that occurs when smoke blocks sunlight. It was reported that smoke particles help in forming water droplets. However, it was not certain how this would affect rainfall. Now Daniel Rosenfeld, an atmospheric scientist at the Hebrew University of Jerusalem, Israel, has shown that smoke from forest fires can, in fact, stop clouds forming raindrops. In other words, smoke tends to prevent rainfall.

Rosenfeld studied simultaneous visual, infrared, and radar observations from the National Aeronautics and Space Administration's (NASA's) Tropical Rainfall Measuring Mission (TRMM) satellite as it passed over Borneo in March 1998, when half of the island was covered with smog. He found that dense smoke completely turned off normal tropical rain. The smoke filled the clouds with tiny particles that made water vapor condense. However, the moisture was divided among so many droplets that they were too small to fall as rain. At the same time, smoke-free clouds over the other half of the island produced ample rainfall (*New Scientist*, Vol. 164, No. 2208).

Rosenfeld believes forest fires are at least partly responsible for the decline in rainfall in the tropics over the past century. "For certain types of clouds, heavy smoke blocks precipitation altogether," he says, adding that smoky tropical clouds can yield some rain only if they rise high enough for water to freeze.

Experts warn that this may lead to disastrous effects on the world's climate. Similar effects seem to be occurring elsewhere, says Christian Kummerow, a project scientist at Goddard Space Flight Center, near Washington, DC.

Anything that affects the rainfall pattern is important. According to Hans Graf of the Max Planck Institute for Meteorology in Hamburg, Germany, about two thirds of the energy that powers the planet's weather depends on the formation and fallout of raindrops.

Source: *Down to Earth*, 15 January 2000. p. 24.

Direct economic impacts of the fires and haze included loss of forest and land resource capital; loss of timber and nontimber forest crops and stocks; damage to infrastructural assets; agricultural crop losses, productivity loss, and falling yields; falls in tourism arrivals and revenue; disruption in commerce; and disarray in transport systems, unplanned cost of fire suppression efforts, health care, and rehabilitation.

Plant growth may also have been affected by the reduction in solar energy as a result of the sun's rays being partially blocked by haze. Photosynthesis may have been further reduced by the deposition of soot particles on leaves. A drop in aquaculture and fisheries productivity also results from a reduction in available solar energy.

More than 40,000 people have sought medical help and hospitalization in Indonesia and Malaysia for smog-related respiratory ailments

Fire affected the marine environment and its biological resources, resulting in increased sediment from burned water catchments. This resulted in a reduction of primary aquatic productivity through light suppression and by imposing stress on filter feeding organisms. The haze also reduced solar radiation and productivity of all species with food chain links to the mangrove ecosystem. Details about the economic impacts of the fires on specific subsectors of the economy can be found in various reports (BAPPENAS 1999, MOE-UNDP 1998, EEP-SEA and WWF 1998b).

Social Costs

Health-related Costs

During the haze, the health of some 40 million people in the region was directly affected. (Some sources estimate the total number of people affected directly and indirectly to be about 70 million.) More than 40,000 people have sought medical help and hospitalization in Indonesia and Malaysia for smog-related respiratory ailments (BAPPENAS 1999).

A rapid survey by the Japan Medical Team for Disaster Relief in October 1997[17] assessed the effects of haze pollution on human health in the Province of Jambi, Sumatra. The survey indicated that 98.7 percent of the people complained of at least one symptom and 91.1 percent of the people complained of at least one respiratory symptom after the haze. A physical examination revealed that 33.3 percent of tested people suffered from conjunctivitis, 8.9 percent stridor, and 2.9 percent rale (Obayashi 1998).

The United Nations Disaster Assessment and Coordination (UNDAC) Mission on Forest Fires conducted assessments of land and forest fires in several countries, including Brunei Darussalam, Indonesia, Malaysia, Philippines, Singapore, and Thailand, in September-October 1997. The team reported that 11 people died and 23,000 people suffered from respiratory diseases in Central Kalimantan. In Jambi, 35,368 cases of upper respiratory tract infections were reported, while in West Sumatra the number was even higher (47,565 cases). South Sumatra also recorded a number of diarrhea cases during the haze.

The Indonesian Ministry of Health estimated after the 1997-1998 fires that the haze-related health problems affected 240,000 people in the country. The total number of deaths, severe asthma cases, bronchitis, and acute respiratory infection cases in eight provinces of Kalimantan and Sumatra was about 2,000. These numbers reflect the health problems caused by PM_{10} and do not include effects associated with other pollutants.

A study on asthma attacks among children revealed that a high concentration of fire-generated carbon monoxide, nitrogen dioxide, and inhalable suspended particulate matter (PM_{10}) was responsible for the health problems (ASEAN 1998a).

Other Social Costs

Other social impacts of forest and landfires have included damage to heritage sites, graveyards, tribal houses, and shelters in the rice fields.

Environmental Costs

Environmental costs include those resulting from ecological and related impacts of fires on plant, wildlife, soil, air, water, biodiversity, and global climate, and a diminution of the environmental services of the forests.

Ecological impacts of wildfire of 1997-1998 included adverse ecological changes affecting terrestrial, aquatic, marine, and agricultural ecosystems; reduction in ecosystem functioning and landscape stability; damage to wildlife, wildlife habitat, and protected areas; loss of sequestered carbon, emission of greenhouse gases and contribution to global warming; microclimatic changes; air pollution; water quality changes, reduction in water yield; increased soil erosion, loss of soil nutrients and fall in productivity; plant mortality, loss of forest growing stock, damage to regeneration, spread of *alang alang*, and forest degradation/ deforestation; erosion of biodiversity affecting ecosystem, species, and genetic variability; and loss of environmental heritage—all affecting the potential sustainability of development.

Biodiversity Loss

There has been loss of biodiversity as a result of the 1997-1998 fires, which caused increased degradation of globally important protected areas such as Kutai National Park. The 1997-1998 fires destroyed most of East Kalimantan's Kutai National Park and Bukit Suharto Nature Reserve. Some 85 percent of Wanareset (research forest) was also burned. Severe damage was not limited to natural biodiversity, but also included agricultural ecosystems. A great deal of the forest burned was secondary, resulting in depleted biodiversity.

In Iriyan Jaya, Kalimantan, and Sumatra, a particularly dangerous ecological impact has been the degradation of large areas of peat soils through fire. Extensive fire damage to the peat soils of the swamp forest ecosystem is also expected to accelerate the changes brought about by draining of these swamps for agricultural expansion, and drastically alter the role of this ecosystem in water storage to sustain regional forest, agricultural, and aquatic ecosystems.

Wildlife Decline

The fires affected not only humans but also wildlife. A drop in the numbers of rare and endangered animal species caused directly by fires has been compounded by the hunting of disoriented animals for food and for sale.

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WWF Indonesia in a news release of 17 December 1998 claimed a decrease in the population of orangutans (*Pongo pygmaeus*) as a result of forest fires in 1997-1998 in Indonesia and Malaysia. In Borneo and Sumatra, orangutans were forced to flee the forests due to the heat and smoke. Hunger, too, drove them out of the forests as the fires destroyed the fruits on which the orangutans feed.

The Kalimantan fires have reduced the orangutan habitats by some 40 percent, worsening a decline estimated by WWF (1998) at 80 percent in the 1970s and 1980s. Destruction occurred not only to the orangutans' habitat but also to the habitats of other flora and fauna. Efforts must be made urgently to protect these important habitats.

Estimated Value of Total Costs

There have been several attempts to estimate the value of all the losses caused by the fires and haze. Insufficient data and the differences in the methods adopted have caused considerable variation. Nevertheless, the economic costs have been significant, irrespective of the methodology. Some details of 1982-1983 and 1997-1998 fires in Indonesia are provided, as an illustration.

Fires of 1982-1983

Economic losses due to the 1982-1983 fires are estimated at $9 billion (Table 4). This amount is three times the total annual revenue from the forestry sector in 1980, which totaled $3 billion (MOE-UNDP 1998).

In addition to the opportunity costs incurred by the State, local communities also experienced significant losses. Mayer (1989) reported that food, water, and forest supplies were diminished, access to remote communities was blocked, and income was reduced. According to Mackie (1984), damage to pepper crops alone amounted to $2 billion.

Thus, the estimate of losses, while significant, is only partial as the socioeconomic costs have not been fully accounted for.

Fires of 1997–1998

Since the fire season of 1997-1998 continued in two sequences over two calendar years, there are several valuations of losses—preliminary, detailed, by individual years, and by individual sectors of economy; covering host and recipient countries of haze impact; and more comprehensive ones covering all the fires.

One of the more comprehensive estimates was prepared by the Asian Development Bank (ADB). It includes losses covering forestland (timber, NWFPs, reduced/impaired growth), biodiversity, spiritual and cultural values, indirect benefits, carbon sequestered, plantations, estate crops, agricultural crops, and tourism, as well as additional costs incurred for treating haze-related ailments and firefighting.

This valuation builds on previous estimates but includes the cost of the 1998 fires. A modeling approach was used so that the estimates can be updated when more data become available. The approach to valuing the losses has been to sum the value of the individual components, each of which uses the most appropriate technique.

The total losses resulting from the 1997-1998 fires and haze have been estimated at between $8.8 billion and $9.7 billion, with an average of $9.3 billion. A summary of these costs is given in Table 5. With all their negative impacts, and heavy socioeconomic and environmental costs, the fires exposed the weaknesses of government policies in Indonesia.

The reform package introduced by the Government in April 1998 to the International Monetary Fund and further described in the Memorandum of Economic and Financial Policies of 29 July 1998 reflects the measures and targets set to correct the situation. The fires also elicited spontaneous responses regionally, nationally, and internationally in the form of concrete support and action.

TABLE 4 Losses Resulting from Forest Fires in East Kalimantan, 1982–1983

Source of Loss	Value ($ billion)
Timber from Natural Forest	7,981
Timber from Swamp Forest	348
Nonwood Forest Products	373
Rehabilitation Expenses	352
Total	**9,054**

Source: Schindler et al. 1989a, b.

TABLE 5 Summary of Costs of the 1997–1998 Fires in Indonesia

Sector	Estimated Economic Losses ($ million) Minimum	Maximum	Mean
Agriculture			
Farm Crops	2,431	2,431	2,431
Plantation Crops	319	319	319
Forestry			
Timber from Natural Forest (logged and unlogged)	1,461	2,165	1,813
Lost Growth in Natural Forest	256	377	316
Timber from Plantations	94	94	94
Nonwood Forest Products	586	586	586
Flood Protection	404	404	404
Erosion and Siltation	1,586	1,586	1,586
Carbon Sink	1,446	1,446	1,446
Health	145	145	145
Transmigration, Buildings, and Property	1	1	1
Transportation	18	49	33
Tourism	111	111	111
Firefighting Costs	12	11	12
Total	**8,870**	**9,726**	**9,298**

Source: Final Report, ADTA INO 2999: *Planning for Fire Prevention and Drought Management* (BAPPENAS 1999).

Notes

[6] Member countries of ASEAN are Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Viet Nam.

[7] For definition see Glossary in Appendix 1.

[8] For definition see Glossary in Appendix 1.

[9] Several reports and papers including the WWF discussion papers "The Year the World Caught Fire" (WWF 1997) and "The Fire This Time" (Schweithelm 1998a) contain an overview of the Indonesian wildfires in 1997 and 1998.

[10] Ground surveys made by Lennertz and Panzer (Panzer 1989) in timber concessions throughout the burned area have provided proof that damage was generally heavier in logged-over than in primary forests.

[11] The situation has been the same for several years. A seminar on Forest Fire and Satellite Data Utilization held in Jakarta in September 1987 revealed that the Ministry of Forestry had been unable to deal comprehensively with forest fires due to shortage of funds (GOI/FAO 1990b). Investigations indicated that the country's multimillion dollar reforestation fund, collected on timber produced, had not been used to fight fires or set up antifire defenses.

[12] The Indonesian Government has been somewhat late in reacting to fire warnings; data on hot spots were available during January/May 1997, and yet there was no timely proactive initiative. Even after news releases were made of an impending ENSO, land preparation burnings continued as usual in August 1997.

[13] In Indonesia, during the 1997-1998 fires and haze, intersectoral coordination at the central level was not effective due to inadequate institutions, including unclear assignment of tasks, authority, and responsibilities among the relevant institutions, especially in the mobilization of personnel, equipment, and financial resources, as well as reporting and information dissemination. These problems were also seen at provincial and district levels. Donor assistance does not come from a single source using a clearly defined mechanism. Some is received directly by MOFEC, some through the BAKORNAS PB, and others go directly to the provinces. Exchange of information is not well organized, which complicates monitoring of the assistance (BAPPENAS/ JICA/ITTO 1999).

[14] ADTA INO 2999: *Planning for Fire Prevention and Drought Management.*

[15] Apart from the impact of particulate matter on health, it could also affect the long-term global temperature balance by disturbing the evaporation-condensation cycle.

[16] ADB under its ADTA INO 2999 estimated that a total of 757 million mt of carbon dioxide were produced during the 1997 and 1998 fires (more than 85 percent of this was as a result of the combustion of peat). The total cost of the carbon released into the atmosphere (based on $7/mt) was calculated to be $1.446 billion. This figure is conservative; other estimates have put the amount of carbon dioxide produced at 3.7 billion mt, or nearly five times the level estimated by the technical assistance.

[17] Within about two to three months of the forest fires and haze.

CHAPTER 3

Responses to Fires and Haze in the Region

[This chapter discusses the varied responses, at several levels, to the recent fires and haze, particularly those of 1997-1998, and analyzes trends in donor assistance.]

Nature of Initiatives

There have been various responses to past fire outbreaks, but the recent round of fires in Indonesia and neighboring countries led to several new initiatives, and the reviving or revamping of old ones, to address the problem.[18]

The new initiatives in response to the 1997-1998 fires included formulation of national strategies for coordinated action, regional efforts within ASEAN, and international support. Many countries and international organizations have provided emergency assistance in cash and kind, including equipment, materials, medicine, and firefighters. Some of these initiatives had emergency and disaster abatement dimensions. Others had short-term (for addressing damage control) and medium- and long-term (sustainable improvement) perspectives. Some of the post-fire initiatives involving reviews, planning, and investment studies belong to the latter category, supporting sustainable development.

To help establish and ensure effective coordination of these mutually reinforcing initiatives, ADB has provided technical assistance at the regional level to the ASEAN Secretariat and advisory technical assistance at the national level to Indonesia (see also Chapter 4).

In the 1990s, the world focused its attention on sustainable development and sustainable forest management. Indonesia, for its part, has reported that in response to UNCED decisions, *Agenda 21*, and Forest Principles, it has developed a framework to strengthen national efforts to realize proposals of the Intergovernmental Panel on Forests (IPF), which included protection of forests from fires (GOI/MOFEC 1998c).

The aftermath of a forest fire, Indonesia, 1998.

Photo: Anonymous

ASEAN Response to Fires and Haze

Nearly all of the fires and haze in the ASEAN region over the past two decades have been caused by direct human interference rather than occurring naturally. This means that control of fire and haze is within the collective grasp of AMCs, a fact that has not been lost on ASEAN.

Collective Commitments

Beginning in the early 1980s, AMCs launched several national and regional initiatives aimed at controlling these problems. The first of these, with far-reaching regional influence, occurred in 1985 with the adoption of the Agreement on the Conservation of Nature and Natural Resources, which made specific reference to air pollution and "transfrontier environmental effects."

Between 1990 and 1997, ASEAN initiatives targeted control of fires and haze. Transboundary atmospheric pollution was also highlighted in the 1990 Kuala Lumpur Accord on Environment and Development. Environmental pollution issues were again extensively discussed at the Bandung Conference of 1992, which itself gave rise to a number of workshops and meetings on transboundary atmospheric pollution, held in Indonesia and Malaysia between 1992 and 1995.

The 1992 Singapore Summit identified transboundary pollution as one of ASEAN's major environmental concerns and addressed it in its 1992 Singapore Resolution on Environment. Concern over transboundary atmospheric pollution was once again voiced in the 1994 Bandar Seri Begawan Resolution on Environment and Development.

At the informal ASEAN Ministerial Meeting on Environment (AMME) held in Kuching, Malaysia, on 21 October 1994, environment ministers discussed transboundary pollution and agreed that ASEAN should collaborate actively to build up its member countries' expertise and capacity to address the problem, as well as to minimize its effects. As a result, an ASEAN Meeting on the Management of Transboundary Pollution was convened in Kuala Lumpur in June 1995, at which the ASEAN Cooperation Plan on Transboundary Pollution was adopted.

Haze Technical Task Force

Three months later in September 1995, the ASEAN Senior Officials on Environment (ASOEN) convened their sixth meeting in Bali, Indonesia, at which they established a Haze Technical Task Force (HTTF).

HTTF's initial objective was to put into operation the measures included in the 1995 ASEAN Cooperation Plan on Transboundary Pollution, relating to atmospheric pollution, including the following tasks:

- demarcate critical areas of land and forest fires;
- identify the critical periods for occurrence of haze;
- develop a system for National Focal Points to alert ASOEN on impending haze;
- organize proper collection and effective dissemination of meteorological data, including satellite photographs of "hot spots" by the ASEAN Specialized Meteorological Centre (ASMC) in Singapore and the countries concerned;
- develop a proper monitoring system for actions taken on the ground to fight and contain land and forest fires; and
- monitor and report on the status of projects relating to the management and control of transboundary haze pollution involving international organizations and developed countries.

HTTF was also charged with producing a manual on implementing measures to mitigate and control haze-causing land and forest fires.

However, the absence of specific operational directives rendered the cooperation plan ineffective. Consequently, ASEAN faced more major transboundary pollution in 1997.

The HTTF, which includes all AMCs and is chaired by Indonesia, met for the first time in Jakarta on 16-17 October 1995.

> The absence of specific operational plans rendered the cooperation plan ineffective. Consequently, ASEAN faced more major transboundary pollution in 1997

Following the 1997 fires, the affected AMCs assumed a more operational stance toward the fire and haze disasters than previously

Following the 1997 fires, the affected AMCs assumed a more operational stance toward the fire and haze disasters than previously. Indonesia and Malaysia signed a bilateral memorandum of understanding on 11 December 1997 that allowed the two countries to jointly address certain aspects of transboundary haze and to undertake joint responses to other disasters. Malaysia supported Indonesia with personnel and equipment for firefighting.

Regional Haze Action Plan

At the ASEAN level, a Regional Haze Action Plan (RHAP) was formulated by HTTF and endorsed by the ASEAN Ministerial Meeting on Haze (AMMH)[19] held in Singapore on 22-23 December 1997. The signing of this instrument, the third of its type to be endorsed by the AMCs, has proven to be a turning point in the region's approach to preventing and mitigating the damage from recurrent fires and haze.

Objectives of Haze Action Plan

The primary objectives of the RHAP are to:

- prevent forest fires through improved natural resource management policies and enforcement of relevant legislation;
- establish operational procedures for monitoring land and forest fires; and
- strengthen regional firefighting capabilities as well as other mitigation measures.

An operating assumption of the RHAP is that developing fire suppression mobilization and response strategies at national and regional levels is necessary if future fire-and-haze disasters on the scale of that of 1997 are to be avoided (see Appendix 2).

The signing of the RHAP by the nine ASEAN Environment Ministers signaled a new stance toward ASEAN multilateral cooperation in confronting regionwide fire and haze disasters. The two previous "action plans" were, in fact, strategy documents that provided a broad-brush description of the steps the region should take in mitigating the impact of transboundary haze.[20] In contrast, the RHAP has an operational focus, the intent of which is to identify actions to be taken by specific parties at regional, subregional, and national levels for mitigating the impacts of fires and haze.

The RHAP document is, therefore, a reflection of the AMCs' determination to actively tackle the problem rather than simply describing a broad-brush approach to it. This determination to take action is obvious from the frequency of the meetings of both HTTF and AMMH, which in 1997 increased sharply relative to previous years. At the peak of the 1997-1998 fires and haze, AMMH meetings were held every six weeks, with the meetings of HTTF and subregional working groups occurring even more frequently.

During the course of these meetings, two points became clear to AMMH. First, the region's fire-and-haze issue constitutes a recurrent problem that is far too large for any one agency to address effectively; coordinated and concerted action by all AMCs, as well as donors, will be required. Second, if the RHAP is to succeed in reducing the prevalence or the impact of transboundary haze, it will have to be fully put into operation.

Scope of Haze Action Plan

Transboundary pollution and other crossborder impacts from fires are issues of regional significance, so it is appropriate that there should be a regional plan to address these.

The term "haze" in the title may raise some doubts and questions. Why haze plan? Why not fire plan? Is haze the only issue of concern to arise from land and forest fires? The word "haze" seems more appropriate, particularly in the regional context as it drifts disastrously over other territories away from the source. It is the "dirty cloud of haze" that gives the fire a regional or transboundary dimension and brings in the social dimension of health and safety. The term "haze" internalizes all the factors leading to the production of haze—the condition of forests, land clearing, combustible residues, and ignition source. To control haze, one has to address all the factors that lead to it. The RHAP is a plan for fire management and more.

The scope of the RHAP includes establishing and enhancing fire prevention; improving capabilities for fire suppression in the event of occurrence to minimize any impact; and strengthening regional mechanisms for fire monitoring and early warning.

The RHAP, thus, has three major components—prevention, mitigation, and monitoring. Specific countries have been designated to spearhead the activities that fall under each of the three RHAP components. Malaysia takes the lead in prevention, Indonesia in mitigation, and Singapore in monitoring of fires and haze. This notwithstanding, all of the AMCs will undertake actions at the national level that relate to all three of the RHAP components. In addition, individual actions supporting prevention, mitigation, and monitoring will also take place at subregional and regional levels.

HTTF realized that it must focus fire management efforts in specific areas. The concept of Subregional Firefighting Arrangements (SRFAs) was endorsed at the third AMMH held in Brunei Darussalam on 4 April 1998; and a work program was initiated to develop SRFAs for Borneo and Sumatra.

Contribution of Regional Institutions

Specific technical/scientific contributions can be provided by individual institutions. Examples of such institutions involved in issues relating to fire and haze include: the Asian Disaster Preparedness Center (ADPC), ASEAN Institute of Forest Management (AIFM), ASMC, and Economic and Environment Program in Southeast Asia (EEP-SEA).

National-Level Initiatives

The Front-Line Countries

The front-line countries that most felt the impacts of the fires were Indonesia and Malaysia, followed by Brunei Darussalam and Singapore.

While the major efforts of firefighting were to be taken up by Indonesia, Brunei Darussalam and Malaysia also experienced their share of fires, though on a considerably smaller scale. All the countries, however, had to fight the haze problem.

National efforts involved priming of organizational arrangements, coordination of activities, relief and rehabilitation measures, and post-fire evaluation. Follow-on actions included formulation and implementation of National Haze Action Plans (NHAPs).

Assessment of Response

The arrangements made to combat fire disasters formed part of an emergency plan. This will require reviews of suitability to develop a stable system of fire management and promotion of forest rehabilitation, consolidation, and long-term development.

An ADB study[21] has investigated these and other institutional issues with regard to Indonesia. One of its major findings was that the roles of agencies involved in fire and disaster management were unclearly defined, and a lead agency for coordination and provision of

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In the ASEAN region, most land and forest fires are detected by local dwellers and ground patrols. Lookout towers are used where available

strategic direction was lacking. This led to confusion where disaster response (relief and aid distribution), interagency coordination (for eliminating duplication and implementing compatible strategies), and fire suppression activities were undertaken by multiple agencies. Many communities did not understand who was in charge, nor did they know whom to turn to for assistance. The question of responsibility for provision of funds for fire suppression was unclear and significant delays in securing approval for funding contributed to confusion in mounting suppression action. In some cases, the delays were so chronic that no fire suppression measures were undertaken (BAPPENAS 1999). While the study had not recommended that a single agency should be responsible for all fire management, there is still room for one agency to play a lead role to coordinate other inputs at national, provincial, and local levels.

Application of Technology

Forest Fires and Haze Monitoring

In addressing the fires and haze, an important measure, which calls for reasonably sophisticated technological know-how, is monitoring. Monitoring techniques vary considerably among the AMCs, with respect to fires, haze, and climate change.

Forest Fires

In the ASEAN region, most land and forest fires are detected by local dwellers and ground patrols. Lookout towers are used where available. To a much lesser extent, aerial surveillance is also used to detect fires. Satellite detection of fires is gradually being accepted as an institutional mechanism for fire detection. Satellite detection is cost-effective compared to conventional methods because the satellite can see large areas simultaneously. It can also provide an operational means to monitor fires throughout the year, since these are available on a daily basis.

The most commonly used satellite for fire detection is the NOAA[22] polar orbiting satellite. The satellite carries many sensors on board to measure a host of different parameters on the earth. The sensor to detect forest fires is the AVHRR. It has five channels to measure outgoing radiation from the earth in five different wavebands. The third channel of the AVHRR is sensitive to high temperature targets such as land and forest fires. Thus, by processing the AVHRR data at each pass, it is possible to extract latitude and longitude coordinates of suspected fires daily to a precision of about 1 km, which is the resolution of the AVHRR sensor.

There are many nonmeteorological satellites (NMSs), which also have fire detection capability. The Defense Meteorological Satellite Program (DMSP) Operational Linescan System (OLS) has a unique capability to detect low levels of visible—near infrared—radiance at night.[23] The resolution is similar to that of the NOAA AVHRR sensor. A proposal to make the DMSP/OLS data available to the ASEAN region is being considered. Commercial high-resolution satellite data, e.g., SPOT and LandSat, can provide valuable confirmation and exact coordinates of forest fire locations. However, such data are expensive and not suitable for operational monitoring of fires. Further, these satellites have sampling intervals of two to three weeks, making it impossible to follow the development of forest fires.

A weather satellite soon to be launched by Japan, the Multifunctional Telecommunication Satellite (MTS), will carry a multispectral sensor similar to that on the GOES. This will provide hourly hot spot virtual analysis. However, the resolution of the sensor is about 5 km, making it less precise than the NOAA AVHRR sensor.

Currently, at least five agencies in the region are providing satellite detection of hot spots through ground stations in Bogor, Jakarta, Palembang, Samarinda, and Singapore. While satellite data are vital, there are constraints that require more direct observations be carried out to supplement the satellite information. Satellite detection of fires is often difficult due to:

- inability to penetrate cloud;
- often nonoptimal flyover;
- false alarms from nonfire targets near the threshold temperature;
- poor resolution (1 km at the center, 7 km at the edge), and
- decreased detection performance in heavy smoke haze. (BAPPENAS 1999)

Most of the NMSs have the capability to receive Geostationary Meteorological Satellite (GMS) and NOAA satellite imagery, which means that they theoretically would also be able to detect hot spots and haze. However, some of the NMSs lack the capacity to use this satellite imagery to detect large-scale fires and haze. A training course has been developed by ASMC to help NMSs process satellite data for hot spot detection. Being able to detect hot spots using US NOAA satellite imagery will enable the NMSs to better support their national fire response effort through faster responses to detect fires with their own satellite capability.

Some national-level institutions other than NMSs also have specialized monitoring capabilities, including the ability to determine the exact coordinates of large-scale fires. These include Lambaga Antariksa Penerbangan National or National Institute for Aerospace (LAPAN) of Indonesia and the Malaysian Centre for Remote Sensing (MACRES). This capability allows the NMSs and specialized centers to directly assist national governments in locating land and forest fires, which greatly reduces the amount of time required for dispatching crews to fire sites.

Haze

Available operational monitoring of haze from the ground comes through regular meteorological bulletins required by member countries of the World Meteorological Organization (WMO). The NMSs normally operate an array of ground observing stations within the country. Under WMO requirements, the stations will make reports called Synoptic Reports (SYNOP) at three-hourly intervals. This report will consist of local measurements of temperature, pressure, visibility, reactive humidity, winds, cloud, type of weather, and additional meteorological parameters. The visibility and weather type will reveal details about the extent of haze conditions, if any, at the locality. These will be transmitted through the national telecommunication network to the main weather headquarters. The report will be consolidated along with others across the country and transmitted to WMO countries. Through this method, concerned countries can monitor the haze conditions of designated areas of another country, provided they are also member countries of WMO. The disadvantage is that most of these observing stations are not colocated near the forest fires, therefore the report does not represent the worst conditions.

If the observing station is colocated in an aerodrome, it is also obliged to send hourly reports of weather conditions, called Meteorological Aerodrome Reports (METAR), under International Civil Aviation Organization (ICAO) requirements. The METAR is similar to the SYNOP report and will also reveal the extent of haze conditions nearby.

Aerial reports about haze are occasionally reported by commercial flights traveling in the region. But this reporting is voluntary and the

While satellite data are vital, there are constraints that require that more direct observation be carried out to supplement the satellite information

reporting format does not include a haze description. Occasionally, some pilots will report visibility conditions and haze depth.

The best method of monitoring haze is through remote sensing. The Japanese GMS[24] carries the Visible/Infrared Spin-Scan Radiometer (VISSR), which is capable of detecting smoke haze. Since it is geostationary, it will provide hourly visible images during daytime. With these images available, it is possible to track the development and spread of haze to different regions. GMS, unfortunately, is unable to provide quantitative measurements of haze concentration. Another satellite suited to detect haze is the Total Ozone Mapper Spectrometer (TOMS) sensor on board the Earth Probe (EP) satellite. TOMS can detect smoke particles from a variety of ground-based sources, such as biomass burning, whether naturally occurring or caused by agriculture, oil industry fires, or industrial smoke.

> The best method of monitoring haze is through remote sensing. The Japanese GMS carries the Visible/Infrared Spin-Scan Radiometer, which is capable of detecting smoke haze

The TOMS data are able to provide a quantitative approximation of aerosol concentrations in the haze by correlating to measurements made on the ground. The EP satellite is polar orbiting, like NOAA, therefore only one image is available daily.

Monitoring Experience during 1997–1998 Forest Fires and Haze

Experience of monitoring the 1997-1998 fires and haze in Indonesia, and Brunei Darussalam and Malaysia, are reviewed here.

Indonesia

Fire detection systems in the country use sophisticated technology (satellite imagery) as well as conventional methods such as fire towers and terrestrial patrols.

During the 1997-1998 fires and haze in Indonesia, MOFEC and several other organizations monitored hot spots appearing on NOAA weather satellite images, tracked where fires were burning each day, and provided early warnings about fire dangers to the fire teams through a chain of command structure at national, provincial, and district levels.

There are six NOAA-AVHRR satellite stations in Indonesia. Two in Jakarta are located at the Agency for Meteorology and Geophysics (Badan Meteorologi dan Geofisika or BMG) and LAPAN that are mainly for weather monitoring purposes; and there is one each in Bogor (West Java), Palembang (South Sumatra), Samarinda (East Kalimantan), and Palangkaraya (Central Kalimantan). The specialized system for fire detection and monitoring by satellite is primarily held by the MOFEC with support from funding agency projects. The Bogor station, supported by the Japan International Cooperation Agency (JICA), operates NOAA AVHRR and a smoke-tracking Himawari. Overlaid with NOAA images (hot spots), the Himawari images could confirm the existence of fires. The stations produced hot spot maps daily and sent these to provinces where the hot spots existed. The basic constraint was the poor communication system between stations and receiving addresses (provinces, districts, and fields). This rendered the detection and control system inefficient.

Caution is required in using hot spot data from satellite images to detect and evaluate fires, because of the limitations described earlier. The total number of hot spots counted on images taken during the day decreases on similar images taken at night, probably due to daytime changes in humidity. Hot spots may represent heat sources other than from land and forest fires, including burning coal seams, gas flares, and activities in settlement areas. The information provided also has not always been effective due to the coarse scale (resolution) of the images and communication delays. The experiences of the 1997-1998 fires have shown that much improvement is needed to strengthen the early warning capability through a combination of enforcement and awareness programs at the local level.

While aerial surveillance with multispectral scanners and fire detection by satellite sensors represent the higher side of the technology, at a practical field level it is necessary to have a system of fire (lookout) towers, surveillance teams with two-way communication equipment, fire patrol teams, and local informants for immediate detection of fires. Local villagers are often the key informants and they need to be provided with adequate incentives.

The results of automatic processing of satellite images as well as of surveillance measures must be transmitted immediately to the local firefighting units for ground verification and fire suppression, as warranted. This calls for an effective and efficient communication system, linking all levels in the fire management system.

Aerial surveillance using aircraft or helicopters is limited. Although the aerial surveillance exercises held in Riau by the SRFA-Sumatra found the system to be effective for detecting fires on a real-time basis, it is still considered inefficient due to its high operational costs. MOFEC is cooperating with domestic commercial airlines for surveillance; requiring the airlines to report to the closest airports any fires they spot during their regular flights. Then the airports forward this information to the closest MOFEC office for further action.

Along with information generation, it is essential to ensure that there are adequate capability and preparedness to quickly respond to firefighting needs, including personnel, tools, techniques, skills, infrastructure, and mobility.

Brunei Darussalam

Brunei Darussalam has adequately controlled its forest fire and haze pollution problems. The Fire Services Department, which is responsible for fire and haze management, has developed a national contingency plan for combating fires.

The areas of concern have been compartmentalized into five jurisdictional zones: Commands A, B, C, D, and E. In terms of fire hazard, the Forestry Department established a Fire Hazard Rating and Zoning scheme that is based on the following factors: (i) the presence of communities and settlements, (ii) historical data on frequency of fire occurrence, and (iii) abundance of combustible materials.

Taking these factors into account, the department classified the country into three Fire Hazard Zones: (i) Low Hazard Zone, (ii) Medium Hazard Zone, and (iii) High Hazard Zone. The zoning system is useful in prioritizing or concentrating the surveillance for fire detection and control.

The Government has established an "Airborne Command" stationed at the Royal Brunei Air Force Second Squadron at the international airport. The Command uses helicopters and helitankers for controlling fires, under an operation called "Clear View." This is aimed mainly at providing quick and accurate information for water bombing. It also helps with the early fire detection and warning system. So far, the system has been effective and efficient.

In addition to these sophisticated measures, Brunei Darussalam is still practicing a "word of mouth" approach to fire detection. This encourages citizens to promptly report any fire in their district. The Fire Services Department is promoting this approach through a public relations program.

Local villagers are often the key informants and they need to be provided with adequate incentives

Malaysia

Malaysia has been widely practicing aerial surveillance for fire detection and monitoring, even though it still depends principally on ground patrolling. Hot spot information is received from, among others, the National Meteorological Services. A word of mouth approach is also a component in the system. The people's concerns about the consequences of burning and strict law enforcement have made the approach effective.

Fire Prevention and Mitigation Technology

An analysis of the situation with regard to fire prevention and mitigation as a background for assessing future needs is given later under the respective sections (see Chapter 5).

Acquisition of Technology

Science and technology relating to forest fire covers various aspects; there is need for an appropriate balance of focus, depending on perceived needs.

While most of the skills needed at the field level are to be developed locally, certain sophisticated technology can be acquired through technology transfer

While most of the skills needed at the field level are to be developed locally, certain sophisticated technology can be acquired through technology transfer. The use of geosynchronous satellites and space-borne sensors for early warning of fires and atmospheric pollution; investigation of candidate systems for fire weather and fire danger forecasting; assessing influence of inter-annual climate variability; and interpretation of fire scar characteristics are some of the areas where most tropical countries will need to build national capability. ASMC, BMG, and LAPAN are examples of institutions that can appropriately be strengthened.

Science and technology relating to forest fires at the forest end are weak. There is no long-term research being carried out to address fire-related problem areas. Urgent action is needed to address weaknesses in management and technology.

Southeast Asian Fire Experiment

SEAFIRE is a research project in the planning and preparation phase and will be conducted under a scheme of the International Geosphere-Biosphere Programme (IGBP). The International Global Atmospheric Chemistry (IGAC) project is a core project of IGBP. One of the activities of IGAC (Natural Variability and Anthropogenic Perturbations of the Tropical Atmospheric Chemistry) investigates the impact of biomass burning on the atmosphere and biosphere (Biomass Burning Experiment or BIBEX [http://www.mpch-mainz.mpg.de/~bibex]). SEAFIRE will establish the fire research component within the Integrated Study on Land-Use Change in Southeast Asia, with linkage to other activities of IGBP.

SEAFIRE will explore the ecological impacts of fire in land use (fires used in forest conversion and shifting cultivation, grassland, and seasonally dry forests) and the characteristics, the regional and global means of spreading, and the atmospheric chemical impacts of the resultant smoke. Land and marine sources of trace gases and aerosols will be considered, as well as industrial sources (fossil-fuel burning, secondary chemical products). Special emphasis will be given to climate variability (ENSO vs. non-ENSO). SEAFIRE will also coordinate with other regional activities in fire management and research.

International Response

Most international assistance projects to address Southeast Asia's fires and haze are country projects in Indonesia. Assistance at regional level is mostly in the form of regional seminars and meetings. While there are international assistance projects relating to, or having components of, fire and haze management in some of the other AMCs (e.g., Malaysia, Philippines, and Thailand), details are not available.

Based on experience, many of the projects have undergone revisions and modifications. It was therefore difficult to obtain a fully updated situation.

A list of active funding agency-assisted activities is given in Appendix 5.

Emergency and Immediate Term Assistance, 1997–1998

In spite of Indonesia's experiences of the previous few years with fires and haze and the efforts to build capacity for fire management, the fires of 1997-1998 attained disastrous dimensions as the IDNDR entered its last quarter. This prompted several emergency actions.

In response to the escalating fire and drought emergency, a UNDAC Team was dispatched to Indonesia at the end of September 1997 to provide assistance in terms of needs assessment, resource mobilization, and coordination of international support (Dennis 1998). The UNDAC Team cooperated with the national authorities, local donor country representatives, UN agencies, and international nongovernment organizations (NGOs).

UNEP and the UN Office for the Coordination of Humanitarian Affairs (OCHA) made a joint appeal for emergency assistance to the region. Donors responded with direct financial and in-kind assistance. An OCHA-UNEP mission was again dispatched to Indonesia toward the end of March 1998 to assess the impact of fires in East Kalimantan, with the worsening of drought and fire situation.

Realizing the gravity of the 1997-1998 forest fires, the UN Secretary-General appointed the Executive Director of UNEP to monitor and coordinate the global assistance and expertise provided by international agencies through the UN system. A meeting was organized in Geneva to mobilize resources from the funding agencies. Firefighting experts, other UN agencies, international organizations, and donors were invited to participate. Through its facilities at GRID-Sioux Falls, in the United States, UNEP provided daily satellite images via the Internet showing hot spots and some spatial data layers such as population, elevation, drainage, and land cover to help in fire suppression planning. UNEP also supported a web site showing the biodiversity loss and species in danger due to the forest fires.

Contributions

Emergency assistance in cash and kind (material supplies, equipment, expertise, services of firefighters, use of water bombing aircraft, helicopters, communication facilities, masks, and other types of humanitarian aid) was received from different sources. These included countries such as Australia, Canada, PRC, Denmark, Finland, France, Germany, Japan, Republic of Korea, Malaysia, New Zealand, Norway, Russia, Singapore, Sweden, Switzerland, Thailand, UK, and US, as well as from UN and other agencies including the United Nations Development Programme (UNDP), UNEP, United Nations Children's Fund (UNICEF), United Nations Educational, Scientific and Cultural Organization (UNESCO), WHO, Global Environment Facility (GEF), World Bank, ADB, Organization of Petroleum Exporting Countries (OPEC), EU, and ASEAN. With assistance coming from so many different sources, the problems of coordination were compounded. This assistance represented considerable emergency-related expenditure. For instance, Germany provided about $5.5 million in direct

Emergency assistance in cash and kind (material supplies, equipment, expertise, services of firefighters, use of water bombing aircraft, helicopters, communication facilities, masks and other types of humanitarian aid) was received from different sources

assistance for 15 firefighting vehicles, forest protection equipment for 50 teams of 20 persons each, and small mobile water treatment plants and drilling equipment. The United States contributed a $2 million emergency fund in 1998, in addition to $3.5 million provided earlier.

NGO Relief Efforts

SKEPHI, TELAPAK, Wahana Lingkungan Hidup (WALHI), WWF, and the World Resources Institute (WRI) were some of the international and national NGOs that provided support in addressing the forest fires and haze. The Indonesian NGOs raised public donations for relief projects, supplied masks and medicines, and provided other forms of humanitarian assistance. Forest Watch Network, a global network of NGOs with WRI at the lead, helped raise public awareness and concern about the Indonesian fire disaster. The Forest Watch Network has a central node, regional nodes, and subnodes. TELAPAK, located in Bogor, is Indonesia's nodal organization. Haze Busters based in Singapore funded by Asia Foundation and others, is a unique voluntary effort serving as a link between donors and recipients.

Meetings

A full count of all the national, regional, and global meetings (including conferences, workshops, and seminars) organized by different agencies, on various aspects of the 1997-1998 fires and haze in Southeast Asia is not available. The following are illustrative of the range: Asian Regional Meeting on *El Niño* Related Crisis, 2-6 February 1998, Bangkok, hosted by ADPC and cosponsored by the United States Agency for International Development (USAID)/DFID/NOAA; Asia-Pacific Regional Workshop on Transboundary Atmospheric Pollution, 27-28 May 1998, Singapore, organized by the Germany-Singapore Environmental Technology Agency (GESTA); Bi-Regional Workshop on Health Impacts of Haze Related Air Pollution, Kuala Lumpur, 1-4 June 1998, organized by WHO; JICA/ITTO International Cross-Sectoral Forum on Forest Fire Management in Southeast Asia, 7-8 December 1998 in Jakarta; and Workshop on Regional Transboundary Smoke and Haze in Southeast Asia organized by WMO, 2-5 June 1998, Singapore.

The United States contributed a $2 million emergency fund in 1998, in addition to $3.5 million provided earlier

Medium- and Long-Term Assistance

Early Fire Projects

The 1982-1983 fires and haze brought the issue of (and the need for) forest fire management to world attention. Between 1982 and 1992, short- to medium-term international assistance was provided to Indonesia to address the problem. This included (i) fact-finding, needs assessment, and consultation missions; (ii) emergency assistance; (iii) technical aid and equipment; (iv) training courses and seminars; and (v) management support. Several agencies and countries such as the European Community, FAO, Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ), ITTO, JICA, UNDP, UN Disaster Relief Organization (UNDRO), Australia, Canada, Finland, and United States were involved. During this period, six medium-term projects, two seminars, three training courses, and 10 missions were undertaken.

The Bandung Strategy of 1992

The forest fires and haze of 1991 in Southeast Asia emanated mainly from the Indonesian archipelago. To avoid a recurrence, the Indonesian Government called for international cooperation to support national fire management. In June 1992 an international conference on "long-term integrated forest fire management" was held in Bandung in which national agencies involved in fire management, international development organizations, and potential donors participated. The aim of the conference was to develop the framework for a concerted action plan for Long-Term Integrated Forest Fire Management in Indonesia. The Bandung strategy became a reality in 1994 when the bilateral Indonesian-German project on "integrated forest fire management" became operational, followed by other projects supported by EU and JICA.

Ongoing Pre-1997 Projects

Projects related to land and forest fires are being undertaken by different government and nongovernment agencies, educational institutions, and others (see also Appendix 5). As of September 1998, there were 34 donor-assisted ongoing and planned projects under the purview of MOFEC. Of these, seven projects were directly or indirectly related to forest fire management (FFM). Four of them were long-term projects started after the Bandung meeting, with three projects having forest fires as their main concern.

The four projects are:

(i) GTZ's Integrated Forest Fire Management Project (IFFM) in East Kalimantan (1994-2002);

(ii) JICA's Forest Fire Prevention and Management Project (FFPMP) in Bogor, Jambi, and West Kalimantan (1996-2001);

(iii) EU-Forest Fire Prevention and Control Project (FFPCP) in Southern Sumatra (1995-1998); and

(iv) the Indonesia-UK Tropical Forest Management Programme (ITFMP).

ITFMP was started in 1992 and comprised a number of components related to fires, as part of its overall forest management objective. All four projects have locally installed NOAA AVHRR satellite image receiving systems in order to detect and monitor fire hot spot activity. In addition to strengthening the institutional capacity of MOFEC to deal with fires, FFPCP, IFFM, and FFPMP have also adopted rural or community-based approaches to fire prevention and control.

Achievements of the Early Projects

IFFM. At the village level, socioeconomic studies were carried out to investigate the concept of community-based fire management and organize volunteer fire response crews. Fire centers have been established in 10 forest divisions linked to provincial fire centers. Fire damage rating and early warning systems have been set up and demonstrated, and fire protection equipment and tools supplied and training provided to local people and army personnel. The integration of IFFM into the structures of government forestry departments (central and provincial) provides direct access to those concerned with fire- and haze-related decisions. Planned activities include the preparation of a fire management strategy; setting up of a fire-GIS; refining the early warning and fire detection systems; and undertaking improved training and capacity building programs.

FFPMP. The overall goal of the project is to prevent forest devastation and environmental disturbances caused by wildfires and smoke. The project aims to strengthen the capability of MOFEC at central level, in Jakarta and Bogor, to deal quickly with forest fires and also to improve prevention and initial suppression at the local level. The project components include early warning and detection; a system of forest fire base maps; extension and training in the use of pumps, hoses, and hand tools;

Projects related to land and forest fires are being undertaken by different government and nongovernment agencies, educational institutions, and others

After the 1997 fires, numerous short- and medium-term fire projects were proposed and started

participatory forest fire prevention involving innovative institutional structures; and use of firebreaks, trenches, and fire-resistant tree species, along with other improved land management methods.

For farmers involved in the program, the project provides seeds, seedlings, and fencing materials; while labor is provided on a self-help basis.

FFPCP. The objectives are: (i) to obtain an understanding of the occurrence of fire and the present means of control in the province of South Sumatra; (ii) to develop an operational NOAA fire monitoring and early warning system in Palembang (South Sumatra); and (iii) to establish forest fire prevention and control systems in three different pilot areas representing three important forest types.

Other aspects covered by the project include social forestry, research on fire management and fire risk, and GIS for forest fires.

ITFMP. The emphasis of the program was on sustainable forest management. The program consisted of five projects: senior management advisory team, provincial forest management, forestry research, training, and community-based conservation management. The last project incorporated components relating to forest fires.

Others. Two other projects within the purview of MOFEC with a component on fire management are: (i) forest sector support program and integrated forestry radio communication project with support from EU, and (ii) strengthening the management capabilities of MOFEC, supported by GTZ.

New Fire and Haze-Related Medium-Term Assistance

After the 1997 fires, numerous short- and medium-term fire projects were proposed and started. These have varied in scope, focus, magnitude, and budget, etc. Some were national in coverage, while others are regional. Some of the important ones are briefly described here.

UNEP Initiatives

UNEP is implementing a medium-term project on “Emergency Response to Combat Forest Fires in Indonesia and to Prevent Regional Haze in Southeast Asia.” This project, funded with $750,000 under the GEF, has five major components. Most significant among these is an early warning and emergency response system that uses a combination of aerial surveillance and satellite imagery to detect fires and allows firefighting teams to respond quickly.

Another component of the UNEP project is focusing on development of international agreements relating to transboundary atmospheric pollution. The UNEP project collaborates closely with ADB in this regard, as well as in other subinitiatives to promote the RHAP. UNEP has also helped ASEAN countries in implementing the Sumatra Firefighting Surveillance Pilot Project. It is also assisting other AMCs in developing the ASEAN Protocol/Agreement on Addressing the Regional Fire and Haze Problem.

ITTO-CFC National Guidelines on Forest Fire

This project is being carried out in collaboration with the Directorate General of Nature Conservation (PKA) and Institute Pertanian Bogor (IPB). National guidelines are being finalized. Apart from these, the project envisages several other outputs: skills development, training of trainers, equipment supply, communication development, coordination, financing and budgeting aspects, and public awareness.

GTZ: Sustainable Forest Management Promotion in East Kalimantan

This is a new component on a pilot basis, added to the IFFMP in January 1998 to assist forest enterprises (private and state-owned), and local people to take the necessary steps to rehabilitate fire-affected forests and integrate these into management systems.

WWF-Indonesia

WWF-Indonesia provided additional input in the analysis of the causes and impacts of forest fires and haze and formulation of an Integrated Conservation Development Plan. The latter incorporates a buffer zone protection plan and impact of fires on conservation areas.

UNDP Assistance

UNDP provided support in the preparation of an action plan for prevention and management of forest and land fires. This project has recently been completed. UNDP is concentrating its efforts on immediately strengthening the ability of the Indonesian Government to assess and monitor environmental disasters.

CIFOR-ICRAF-UNESCO Project

This project will study the underlying causes and impacts of fires in Southeast Asia. This is a three-year in-depth study. The Centre for International Forestry Research (CIFOR), International Centre for Research in Agroforestry (ICRAF), and UNESCO propose a three-tiered approach: (i) a general overview of the fire situation in the Indonesian archipelago; (ii) a more detailed assessment in Kalimantan and Sumatra (to assess how their fire characteristics are representative of Indonesia as a whole); and (iii) a detailed assessment of causes and effects at specific sites (in Kalimantan and Sumatra).

The research is designed in a modular way; with each module standing independently, but complementing and supporting the others (CIFOR-ICRAF-UNESCO 1998).

The combined expertise and field knowledge of these three institutions is unique in supporting the study. While some funding commitments have already been received, more are expected soon.

ADB Assistance Program

ADB's assistance on forest fires has included two separate but interrelated technical assistance projects (see Chapter 4). The first of these is ADB support for a national initiative through an ADTA to Indonesia. This will assess the extent of economic damage caused by uncontrolled fires in 1997 and assist the Government to bring about the necessary policy reforms and investments in prevention of future fire disasters and better management of droughts.

The second project consists of support to ASEAN through a regional technical assistance (RETA) project for strengthening ASEAN's capacity in preventing and mitigating transboundary atmospheric pollution resulting from the forest fires, and improving cooperation among fire and smoke-affected ASEAN countries.

ADB (through the latter project) and ASEAN were instrumental in mobilizing support of other donors and establishing partnership arrangements to address forest fires and haze. The following three assistance programs were catalyzed by ADB/ASEAN.

WMO Program to Address Regional Transboundary Smoke (PARTS)

PARTS was formulated by WMO in 1995 in response to a collective request from AMCs. It consists of three components.

ADB and ASEAN were instrumental in mobilizing support of other donors and establishing partnership arrangements to address forest fires and haze in the region

All the three PARTS components include technical assistance and training via workshops, and twinning arrangements such as exchange visits that emphasize on-the-job training

(1) *Upgrading of ASMC's capability in the use of satellite imagery to detect fires and haze*. This includes automated fire detection, upgrading of hardware in preparation for the coming generation of satellites and sensors, expanding ASMC's capability in analyzing the chemical composition of smoke plumes, and developing satellite-based meteorological surveillance techniques of selected AMC national meteorological services.

(2) *Upgrading of the region's capability in the modeling of long-range transport of haze and other pollutants*. This will involve installation of atmospheric transport models at ASMC's facility in Singapore, training of ASMC staff in the use of their models, and visits of ASMC staff to NOAA facilities in the US.

(3) *Designing and implementing a strategy for regional monitoring of transboundary atmospheric pollution* with assistance from appropriate international experts.

All the three PARTS components include technical assistance and training via workshops, and twinning arrangements such as exchange visits that emphasize on-the-job training.

The Australian Government will directly finance PARTS component 1 as one of three of its initiatives for assisting ASEAN in addressing the impacts of fire and haze in the region.

The US Government will finance PARTS components 2 and 3 as two separate subprojects under the Southeast Asian Environment Initiative (SEA-EI).

Australian Assistance

Australian assistance is provided through a project to combat fires and haze in Southeast Asia. This project, running for two years, covers Indonesia and Malaysia. There are three components covering fire prevention, mitigation, and funding of PARTS.

- Improving the capability for using satellite technology for fire and haze detection and monitoring at ASMC, in association with relevant national-level institutions (component 1 of PARTS).
- A program directly contributing to ADB's RETA 5778, consisting of three subcomponents:
  - (i) support for an Applied Study on Formulating a Regional Fire Suppression Training and Research Program;
  - (ii) support for an Applied Study on Strengthening NHAPs for AMCs, with particular reference to Indonesia; and
  - (iii) support for an Applied Study on Formulating a Framework for a Fire Suppression Mobilization and Response Plan, with particular reference to Indonesia.
- Support for training in fire mitigation and prevention, which will build on the Applied Study on Formulating a Regional Fire Suppression Training and Research Program.

US Assistance under SEA-EI

SEA-EI is a regional assistance program package consisting of US contributions through different agencies for 10 projects under three groups: forest management, fire prevention, and firefighting; and climate prediction and environmental monitoring.

The 10 projects are as follows:

- causes and impacts of forest fires in Southeast Asia—technical assistance to CIFOR/ICRAF;
- reduced impact logging—extension of the

technology including training;

- alternatives to slash-and-burn agriculture;
- subregional fire disaster response coordination;
- coal and peat fire suppression. This has two components: (i) building capacity to extinguish coal seam fires in Indonesia, and (ii) assessing peat fires in eastern Malaysia. Assistance is provided through the Indonesian Ministry of Mines and Energy and Malaysian Fire and Rescue Department;
- climate impact forecasting: establish climate models that will generate and distribute regional climate forecasts up to one year in advance;
- atmospheric modeling capacity: to help develop and enhance the region's atmosphere modeling capability in ASMC (component 2 of PARTS);
- smoke and haze monitoring: assistance to enhance the region's physical monitoring capacity (component 3 of PARTS);
- disaster reduction applications of climate forecasting: USAID's Office of Foreign Disaster Assistance will work with ADPC in Bangkok; and
- health assessment: providing support to the Malaysian Centre for Disease Control (CDC) to devise health directions to minimize the impact of haze on affected populations.

The US Government has approved more than $5.28 million for this initiative.

Others

There are other initiatives, some of which are self-funded and others fully or partly financed by donors from resources of approved projects. These include: Canadian International Development Agency (CIDA)/ASEAN fire danger rating system for Indonesia; CIDA-BAPPENAS development planning assistance; WHO project on air quality monitoring and mitigation of health implications of forest fire and haze; burned area estimation using SPOT quick-look mosaics and mapping the extent of Indonesian fires by CRISP. There are two EU projects to address tropical deforestation and fires: (i) Fire in Global Resources and Environmental Monitoring, and (ii) Tropical Ecosystem and Environmental Observation by Satellites.

Proposals and Pipeline Projects

Forest Fire Hazard Mapping

UNEP has proposed a project for an Early Warning System and Forest Fire Hazard Mapping in Indonesia.

UNEP has proposed a project for an Early Warning System and Forest Fire Hazard Mapping in Indonesia

The proposed project output will include satellite data to demonstrate technical possibilities, creation of a GIS database, forest fire hazard maps, an early warning system, forest fire models, and improved capacity in fire hazard mapping. The project will address the need for a proper spatial database at 1:50,000 scale with thematic layers (e.g., elevation, hydrology, geology, vegetation, soil, and land use).

Joint ASEAN Program in Fire and Haze Management

This proposal is for the development of an ASEAN-wide fire and smoke management strategy and operational system, by sharing responsibilities and resources, focusing on: prediction of fire hazard and fire effects on ecosystems and atmosphere; detection, monitoring, and evaluating fires; and sharing fire suppression technologies and resources (this program is expected to evolve during the Operationalized Regional Haze Action Plan [ORHAP] and would eventually represent its ASEAN core program).

Project Firefight

A World Conservation Union and WWF Project, Firefight, proposes to establish a global network for forest fire prevention and control. The project aims to raise public awareness about the dangers of fires; improve forest fire management worldwide; and eliminate adverse environmental, social, and economic impacts of forest fires (IUCN/WWF 1998).

Technology Assessment and Applications

The application of modern technology to the different aspects of fire management such as weather monitoring, wide-area surveillance, and speedy communication is being discussed as a potential project of vital importance to the region and some of the major donors appear to be interested.

A trend in the new generation fire projects is the emphasis given to sophisticated space-borne remote sensing technology of monitoring and prediction, compared to practical presuppression and suppression

Trends in Fire and Haze Projects

After studying in detail the objectives and activities of 35 projects, training courses, and missions, Dennis (1998) observes that fire projects arise out of extreme fire outbreaks. The worse the problem, the more likely attention will be attracted, with the two experiencing a direct functional relationship. Interest in fire has only been short-lived after a spurt of activities following a major blaze.

Earlier projects addressed issues of fire prevention and control. After the 1994 fires, which created extreme transboundary pollution, the projects also started focusing on the causes. Of the 35 projects, missions, and training courses, six are mainly directed at understanding the problem, 19 at doing something practical, and 10 address both issues. Most current projects are of short-term scope, investigating the underlying causes. Some address specific aspects, such as capacity building and biodiversity conservation. In the case of several recent projects, there are overlaps or similarities in objectives, activities, inputs, and outputs, even though their geographical locations differ. A lesson to be learned from the degree of overlap is that cooperation, openness, and dissemination of results among projects and the relevant government departments is of paramount importance.

A trend in the new generation fire projects is the emphasis given to sophisticated space-borne remote sensing technology of monitoring and prediction, compared to practical presuppression and suppression. There are also no projects that seriously address post-fire rehabilitation. Because of the difference in technological competencies and conditions between these two levels, a barrier to the transfer of technology, even the transfer of information, is created. The projects analyzed were implemented by different national agencies, further creating problems of coordination and counterpart support (Dennis 1998).

In Indonesia, the bulk of the fire projects arising from the 1997 disaster deals with assessment of damage and development of capacities to undertake necessary activities to prevent, monitor, and control fires. However, no direct provision was made for facing the reemergence of such devastating fires, so soon, in 1998. There was, therefore, no adequate source of funding to fight the 1998 fires in East Kalimantan other than that provided by the Indonesian Government.

Neighboring Sarawak, on the other hand, has no exclusive or major forest fire projects and the current projects emphasize sustainable model forest management. Yet, Sarawak's forests have been comparatively safe from fire. It has to be said, however, that the 1998 fires in East Kalimantan would have overtaxed any fire suppression arrangements, in the absence of an adequately planned integrated approach.

Notes

[18] A comprehensive account of past, present, and proposed fire projects in Indonesia during 1982-1998, with details such as objectives, component activities, target groups, geographical coverage, time horizon, counterpart agency, budget level, and where relevant, achievements and impacts, can be found on the Southeast Asia web site of the Global Fire Monitoring Center (http://www.uni-freiburg.de/fireglobe) and in a recent publication of CIFOR-ICRAF-UNESCO-EU, *A Review of Fire Projects in Indonesia (1982-1998)* by Rona Dennis (1998). The book covers the history of fires, forest fire activities of donor countries, ongoing and proposed fire projects, projects in the aftermath of the 1997 fires, Indonesia's response to the fires and smoke haze, and international relief assistance.

[19] AMMH is in fact a meeting of the ASEAN Ministers of Environment focusing on haze.

[20] The two previous "action plans" referred to are: (i) the Long-Term Integrated Forest Fire Management Strategy for Indonesia, which was one of the outputs of the Bandung (Indonesia) Conference of 1992; and (ii) the ASEAN Cooperation Plan on Transboundary Pollution, which was adopted at the ASEAN Meeting on the Management of Transboundary Pollution convened in Kuala Lumpur in June 1995.

[21] ADTA INO 2999: *Planning for Forest Fire Prevention and Drought Management.*

[22] The US NOAA satellite is a meteorological satellite and its access is free to member countries of WMO.

[23] This capability enables the instrument to detect clouds illuminated by moonlight; and lights from cities, towns, industrial sites, gas flares, and ephemeral events such as fires and lightning-illuminated clouds.

[24] The GMS satellite is in stationary orbit, at a constant location 36,000 km above the at-risk areas of the ASEAN region.

The Program

"A first rate theory predicts; a second rate theory forbids; and a third rate theory explains after the event"—Aleksander Isaakovich Kitaigordskii

"Present day science and technology offer an opportunity to beautify, in the full sense of the word, life on earth, to create conditions for the all-round development of every individual. But it is this very creation of the human mind and human hands that threatens the very existence of the human race! What a crying contradiction! We want science to cease to be the servant of two masters—life and death. We want it to serve life only"—Mikhail Gorbachev

CHAPTER 4

The Asian Development Bank's Technical Assistance

[This chapter gives a brief account of ADB's two-pronged approach to address transboundary atmospheric pollution in the region through an advisory technical assistance grant to Indonesia and a regional technical assistance grant to ASEAN. It explains the catalytic role, objectives, and activities of the regional technical assistance, as well as the results achieved and the lessons learned.]

Role and Concerns of ADB

ADB has played a prominent role in promoting the development of the Asian and Pacific region. ADB's concerns, and therefore its operations, cover a wide spectrum of development activities. Its overarching objective is poverty reduction, while its medium-term strategic objectives are to foster economic growth, improve the status of women and disadvantaged groups, support human resource development, help to sustainably manage natural resources, and protect the environment.

Apart from loans and equity investments, ADB provides technical assistance grants for the preparation and execution of development projects and programs, and also for advisory purposes. It gives priority to regional, subregional, and national projects and programs that contribute to the harmonious development of the region as a whole and that promote regional cooperation.

Training of Indonesian firefighters in the use of spray chemicals, 1997.

Photo: Anonymous

Environmental Concerns

In 1996, ADB in collaboration with Harvard University completed a research study on environmental indicators. Three sets of indexes for monitoring environmental changes were developed: cost of remediation, environmental elasticity, and environmental diamond.

The cost of remediation reflects the cost of moving the environment from its present state to a more desirable level in the future. This index has strong policy implications for national governments and multilateral financing institutions (MFIs) since it reveals the amount of wealth that a society has to forego to restore the environment to a more livable level. The index relates environment to the cost of repairing damage done to it in dollar terms.

Environmental elasticity is a dynamic ratio that measures the percentage change of an aggregate measure of environmental quality for every 1 percent increase of a country's per capita gross domestic product (GDP). The environmental changes are generally defined by several selected environmental indicators and are aggregated through a weighting scheme.

The environmental diamond measures and presents the state of the environment graphically, in terms of overall quality of air, water, land, and ecosystem. This indicator reveals a general picture without concealing the multiple dimensions of the environment.

The three indexes can be used by MFIs and governments in determining the state of the environment, the rate of environmental degradation compared to economic growth, and the costs of improving the environment. In terms of environmental investments, MFIs may give added emphasis to countries with negative environmental trends. The green side of environmental degradation (land and ecosystem) should receive greater attention and investments. Systematic and standardized data gathering, however, should be a priority for ADB's developing member countries.

Environmental Challenges

Environment was also one of the major themes of ADB's study on *Emerging Asia: Challenges and Changes*.[25] The study shows that Asia's environment has become so polluted and degraded that it poses a threat not just to the quality of life of its people but also to economic growth. The costs of this environmental neglect are massive.

Many argue that Asia cannot spare the resources needed to clean up its environment. But the solution to Asia's environmental problems does not lie in a mammoth environmental bureaucracy charged with the responsibility of investing billions of dollars in environmental infrastructure. Rather, what is needed is a redeployment of existing resources within the public sector to ensure that environmental issues are fully reflected in macroeconomic and sectoral policies. The environment should be regarded as a dimension that cuts across sectors, policies, and institutions. The energies of the private sector and civil society must also be better harnessed for environmental management.

Unfortunately, Asia's environment is likely to get much worse before it gets better. Most economies are still a long way from the point where rising incomes will create the demands for better environmental standards and induce a shift in economic structure toward less polluting economic activities. However, it would be wrong to conclude that economic growth per se is the cause of Asia's environmental woes. The culprits are failed policies and institutions, and reckless neglect. How to improve policies and establish efficient and effective institutions are expected to be among the major challenges of the 21st century (ADB 1998b).

It is in this context that atmospheric transboundary pollution caused by forest fires assumes significance.

Policy Emphasis on Forestry

ADB plays a leading role in the region supporting and catalyzing action to prevent and mitigate the impact of forest fires and associated transboundary atmospheric pollution.

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ADB's policy emphasis on forestry (and land use) is to promote sustained management of resources, focusing particularly on (i) conservation of ecosystems, species, and biodiversity; (ii) rehabilitation of degraded areas; and (iii) institutional strengthening (ADB 1995). The issue of forest fires and haze in the ASEAN region is a challenging one. ADB's contributions can support the capacity of regional and national institutions to effectively face future fires on a sustainable basis without allowing them to become environmental catastrophes.

Technical Assistance to Address Forest Fires and Haze

Several ADB missions visited Indonesia in late 1997 to take stock of the fires and haze and consider possible responses. Following consultations with national, regional, and international agencies and bilateral donors, as well as with the ASEAN Secretariat, a balanced approach was formulated to address the causes of the economic and environmental damage resulting from these fires, and to prevent their recurrence. ASOEN's HTTF in its November 1997 meeting reviewed a position paper for regional technical assistance. HTTF, while conveying its agreement in principle, suggested that ADB assistance be directed toward putting the RHAP into operation and supporting various economic and scientific studies to enhance understanding of the causes and consequences of forest fires and associated haze formation and dispersion.

Accordingly, a mission to Indonesia, Malaysia, and Singapore in December 1997 met with senior officials of the ministries and departments of environment in the respective countries, the Malaysian Institute of Forest Management in Kuala Lumpur, and ASMC in Singapore, and also participated in the HTTF meeting in Singapore. The mission discussed various initiatives by the region to address the problem of fires and transboundary atmospheric pollution, as well as the key aspects of putting them into operation.

A balanced approach was formulated to address the causes of the economic and environmental damage resulting from these fires, and to prevent their recurrence

The RHAP prepared by HTTF/ASOEN was endorsed by the AMMH held in Singapore from 22 to 23 December 1997 (See Appendix 2).

The RHAP was signed during a period of intense fire, smoke, and transboundary pollution. The document itself is, therefore, a reflection of ASEAN's determination to actively do something about the problem rather than simply describing a broad-brush approach to it. However, the RHAP was formulated and endorsed within such a short space of time that it was not possible for the AMMH or HTTF to work out implementation details prior to its endorsement by the nine AMCs.[26] What the ministers had in mind when they endorsed the RHAP was to initiate a *process*. The document had also made it clear that ADB's assistance would be sought to implement the plan.

Two-Pronged Approach

ADB adopted a two-pronged approach to address the causes and economic and environmental damage from the fires and to prevent their recurrence, supporting regional initiatives as well as national ones. The result was a set of twin projects: a RETA Project[27] for strengthening the capacity of ASEAN to prevent and mitigate transboundary atmospheric pollution, and an ADTA[28] for planning for fire prevention and drought management in Indonesia, approved in early 1998. Both projects have been completed.

Advisory Technical Assistance

ADB approved on 20 March 1998 an ADTA grant for $1 million to the Indonesian Government. The objectives were to assess the damage and economic cost to Indonesia from the 1997-1998 fires and haze, and to formulate an investment plan that would prepare the country for future occurrences and recurrent droughts.

More specifically they are:

(i) to determine the causes of the fires, and the social, environmental, and economic impacts of fire and drought;

(ii) to assess the possible causes of the uncontrolled fires in 1997 and the haze problem, and how these could have been prevented;

(iii) to assess and evaluate policies and regulations relating to the use of fire for site preparation, and the efficacy of methods used in preventing and controlling fire outbreaks;

(iv) to assess the need for new approaches to fire prevention and control; and

(v) to make recommendations on the costs and benefits of investments in prevention, early warning systems, firefighting capability, and institutional strengthening.

The ADTA was completed in April 1999. Details of implementation, outcome, achievements, and proposals for follow-up are provided in a three-volume final report (BAPPENAS 1999).

Regional Technical Assistance Project

ADB approved $1 million for the RETA Project on 24 February 1998 from the Japan Special Fund. The ASEAN Secretariat and associated institutions including ASMC were to provide the counterpart support, including staff, office space, and meteorological equipment (including the supercomputer at ASMC), and other facilities, estimated at an equivalent $200,000.

Objective and Scope

The main objectives of the RETA Project were to strengthen and formalize cooperation among AMCs affected by the fires and haze via support for:

- short-term measures aimed at putting the RHAP into operation;
- medium-term measures that strengthen the capacity of relevant institutions to implement the RHAP, and improve scientific understanding of large-scale fires and transboundary atmospheric pollution; and
- strengthening the capacity of concerned institutions to implement and institutionalize the RHAP.

These aims called for several actions with a view to achieving the following:

- helping to identify actions to be taken by AMCs to put into place an institutional framework for addressing the region's transboundary haze pollution problem on a long-term, sustainable basis;
- identifying the investments (if any) required to support the institutional framework;
- catalyzing donor collaborative partnerships and activities that would directly complement the actions the AMCs planned to undertake in confronting the region's transboundary haze pollution problem;
- sharing knowledge and experience as well as efficient and economic use of regional firefighting equipment;
- developing formalized cooperation arrangements among countries of the region and beyond to enhance the level of scientific understanding of the causes and consequences of transboundary atmospheric pollution; and
- establishing a regional level framework for joint response mechanisms through enhancement in the capacity of ASEAN and associated institutions to effectively implement and monitor the RHAP.

In this regard, the RETA Project's scope of work included:

(i) operationalizing the RHAP (including formulation of a mobilization and response strategy for activating firefighting resources);

> The main objectives of the RETA Project were to strengthen and formalize cooperation among AMCs affected by the fires and haze

The most important task of the RETA Project was to develop a strong and comprehensive time-bound plan for prevention, mitigation, and monitoring at the national and regional levels

(ii) improving the ASEAN Secretariat's information management and dissemination relating to fires and haze;
(iii) strengthening the capacity of ASMC (in Singapore) to allow it to serve as a regional hydrometeorological information center, in collaboration with national counterpart agencies;
(iv) developing appropriate mechanisms for international cooperation for fire prevention and mitigation;
(v) establishing fire detection and monitoring systems at the regional level;
(vi) undertaking socioeconomic and scientific studies with a regional focus that may include:
  (a) use and marketing of biomass and logging residues,
  (b) use of market-based incentives to promote adoption of new products and technologies, and
  (c) transboundary atmospheric pollution; and
(vii) disseminating the results of the studies referred to in v above, as well as information concerning implementation of the RHAP via regional workshops.

The most important task of the RETA Project was to "develop a strong and comprehensive time-bound plan for prevention, mitigation, and monitoring" (as well as institutional strengthening and identifying required investments) at the national and regional levels.

Relationship between the RETA Project and the RHAP

The RETA Project was intended to be part of a process that would lay a strong foundation to address the fire and haze problem in the ASEAN region by putting into operation the RHAP. The ASEAN Secretariat was the implementation agency for the RETA Project; and its Project Management Unit (PMU) was housed within the ASEAN Secretariat Building in Jakarta.

Compared to other areas in which a regional framework has been used to strengthen intra-ASEAN ties (e.g., trade, transport and intraregional tourism—all of which have legally binding instruments concluded), regional cooperation to combat transboundary haze pollution is at a relatively early stage. While a soft-law legal framework for regional cooperation in this has existed since the mid-1980s, few concrete measures have been identified and fewer still have been implemented.

Transboundary haze pollution is a complex issue that requires coordinated concrete measures by a relatively large number of parties if its negative impacts are to be diminished. More important, the action has to be taken before a haze problem develops, so that crises can be avoided or their intensity reduced.

Crisis management by definition involves short-term measures not focused on preventing or reducing the intensity of future disasters.

It is a costly and inefficient means of addressing ASEAN's transboundary haze pollution problem over time. Short-term crisis management initiatives were, therefore, deliberately excluded from the scope of the RETA Project.

Its focus was instead on assisting ASEAN to develop an institutionalized approach to averting or reducing the negative impacts of future transboundary haze.

Implementing the Project

Meetings of the ASEAN Environment Ministers, ASOEN, HTTF, and subregional working groups monitored the progress of the RETA Project and ensured timely action and coordination on bringing the RHAP to fruition.

Within ADB, a Steering Committee, chaired by the Manager of the Environment Division, with representatives from the Office of Environment and Social Development, Forestry and Natural Resources Division West, Forestry and Natural Resources Division East, Programs Department East 2, and Consulting Services Division was set up to oversee implementation, to monitor progress, and to liaise with ASEAN.

The ASEAN Secretariat itself liaised with national governments and agencies, arranged and conducted regional workshops and seminars, and provided necessary administrative support. PMU, meanwhile, took care of the day-to-day administration and management of the RETA Project.

A multidisciplinary team of international and regional consultants assisted the ASEAN Secretariat.

An input of about 60 person-months, comprising 12 person-months of international and 48 person-months of domestic consultants, was involved.

As envisaged in the original project document, the RETA Project was to be implemented over 12 months, with the first three-month phase culminating by the end of May 1998 and resulting in the development of an operational plan.

The second phase was to focus on building a clear understanding of the smoke and haze pollution and to strengthen institutions to address the issues involved.

The Process

The cornerstone on which the RETA Project was built and completed was the RHAP. The specific terms of reference within which the Project functioned were to:

(i) assist ASEAN in formulating a time-bound operational plan that AMCs could use to implement and monitor the RHAP. This aim was achieved by formulating the ORHAP and Detailed Implementation Plans (DIPs);

(ii) create a better understanding of haze formation, movement, and dispersion. This was achieved by initiating ASMC studies on haze formation and movements, in association with partner international institutions;

(iii) strengthen the capacity of ASEAN and national institutions to avoid or face fires and haze. A key instrument in this regard is the proposed ASEAN Agreement on Transboundary Haze, which is supported by legal agreements that will specify various aspects of joint fire management response systems; and harmonize fire detection and monitoring systems, and other outcomes of the program for strengthening ASEAN and national institutions; and

(iv) convene regional workshops, seminars, and training programs to disseminate the results of scientific studies relating to transboundary haze pollution, and discuss their relationship to the overall RHAP implementation process.

The RETA Project was to be implemented over 12 months, with the first three-month phase culminating by the end of May 1998 and resulting in the development of an operational plan

The Activities

The following activities were undertaken to fulfil the major goals:

(i) development of a framework for putting the RHAP into action;

(ii) strengthening of national and subregional plans to address fire and haze issues;

(iii) review of regional policies, and development of strategies and guidelines to promote (a) land-use practices that curb deployment of fire, and (b) market-based instruments that discourage practices that result in fires and emissions;

(iv) review of experiences within and beyond the region concerning fire prevention, control, and mitigation strategies;

(v) an inventory of existing fire management capacity in the affected AMCs to be made available for regional fire suppression efforts;

(vi) formulation of an operating procedure for mobilization of fire suppression resources in each affected country, as well as with cooperating agencies outside the region; development of Fire Suppression Mobilization Plans (FSMPs) and SRFAs.

(vii) development of an improved information management and dissemination system in the ASEAN Secretariat relating to fires and haze;

(viii) strengthening of the capacity of ASMC to serve as a regional hydro-meteorological information center, in collaboration with national meteorological agencies;

(ix) development of regional training and research programs via exchange visits, secondments, and joint training exercises in fire management, remote sensing of fires and haze, application of GIS, and other priority subjects;

(x) undertaking of socioeconomic and scientific studies that enhance understanding of forest fires and haze;

(xi) convening of regional meetings, seminars, and workshops; and

(xiii) establishment of a Coordination and Support Unit (CSU).

Studies Carried out by the Project

When the ASEAN Environment Ministers endorsed the RHAP, two themes stood out as deserving in-depth analysis. First, ASEAN's collective fire management capacity needed to be strengthened. Second, in order to prevent recurrence of similar fires with the return of each ENSO, policies that encouraged adoption of mechanical land-clearing techniques would need to be put in place.

Mobilization of Donor Support

In tandem with the Inception Workshop of the Project, early in 1998, an open forum for funding agencies' participation in assistance for the fire and haze problem was held. This led to a number of commitments complementing the Project activities, with the donors taking over some of the activities within the RETA Project's scope. The resources so released were used to finance other important activities that had been underfunded.

The RETA Project thus promoted collaborative programs with various donors, including the Australian Agency for International Development (AusAID), CIDA, the Governments of New Zealand, Norway, and the United States (under its SEA-EI), and UNEP. Several donors are also working with CSU on forest fires and haze pollution management.

Main Outcome of the RETA Project

The prime output of the RETA Project was an operationalized version of the RHAP (ORHAP) which was approved for implementation by the ASOEN/HTTF in July 1999. The ORHAP includes priority actions for prevention, mitigation, and monitoring of fires and haze, and is composed of one regional, two subregional, and nine national DIPs. The ORHAP requires execution of a relatively large number of interdependent initiatives that complement one another and fit together into an overall framework.

The prime output of the RETA Project was an operationalized version of the RHAP (ORHAP) which was approved for implementation by the ASOEN/HTTF in July 1999

The RETA Project report contains definitions of program components; generic guidelines for implementing the ORHAP; a detailed ORHAP providing descriptive summary of actions; NHAPs and two SRFAs; an annual operational plan and a six-year rolling plan for implementing the ORHAP; procedure for formulating rolling six-year programs; procedures for implementing specific portions of ORHAP and criteria for choosing from the alternatives; Fire Suppression Mobilization Plans (FSMPs) and procedures for formulating and implementing them; details of existing and required regional legal frameworks at the ASEAN level; particulars about a fire-and-haze information clearinghouse; and monitoring framework and establishment of a CSU at the ASEAN Secretariat for undertaking the continued refining and implementation of the ORHAP.

The ORHAP has had a beneficial impact on ASEAN in two respects. First, it has helped ASEAN to address the fire-and-haze issue directly, with actions that increasing the region's capacity to manage future incidents. It has also sparked the beginning of ASEAN's reorientation from a passive agency that responds to challenges in an ex post manner, to a more forward-looking institution that anticipates challenges and responds to them ex ante.

The regional level coordination, support, and monitoring of the ORHAP has been institutionalized through establishment of CSU, which fully took over the coordination and support functions with effect from 1 October 1999. A web site (http://www.haze.online.or.id) was also set up for online information exchange and updates. CSU acts as a clearinghouse for potential collaborative programs for bilateral and multilateral assistance aimed at prevention and mitigation of forest fires and associated transboundary haze pollution.

The ORHAP requires execution of a relatively large number of interdependent initiatives that complement one another and fit together into an overall framework

BOX 11 Achievements of ADB's Regional Technical Assistance Project

A. Through direct intervention

- Compiled baseline information through surveys, studies, and assessments.
- Conducted inventory of the region's firefighting resources and fire suppression capabilities.
- Established and strengthened subregional firefighting arrangements.
- Carried out studies on ASEAN's existing fire and haze monitoring system with a view to upgrading them.
- Undertook policy studies on the use of market-based instruments for promoting adoption of mechanical zero-burn land-clearing methods and marketing of products that use biomass residues as productive inputs.
- Reviewed national and international laws, policies, and institutional arrangements relating to fire and haze issues and developed a legal framework and facility for crossborder cooperation.
- Catalyzed development of regional and national facilities for fire and haze monitoring.
- Developed and strengthened the system of information management at the ASEAN level and supported establishment of a regional information center and clearinghouse including setting up of a haze web site.
- Helped put in place an Operationalized Regional Haze Action Plan, including a system of Detailed Implementation Plans at the regional, subregional, and national levels.
- Assisted in organizing institutional mechanisms, particularly for regional coordination, through establishment of CSU.
- Promoted dialogue among ASEAN members and partners as a long-term system for effective regional cooperation.

B. Through collaboration with other donors

- Formulated an operating procedure for activating forest firefighting resources in the ASEAN region, with particular reference to Indonesia.
- Designed a model FSMP and initiated preparation of FSMPs for specific areas.
- Conducted studies on haze transport and climate models and harmonization of pollution indexes.
- Catalyzed and collaborated in studies on health impacts of haze pollution.
- Promoted development of facilities for training and research relating to forest fire and haze management.
- Mobilized donor support for fire and haze projects (e.g., PARTS), forged collaborative partnerships with other international institutions, and facilitated donor coordination.

Throughout the RETA Project, PMU has provided support in the formulation of the AMCs' NHAPs. The numbers of studies and analyses carried out by the team have been substantial and will be useful during the implementation of the ORHAP and also as reference materials.

Notes

[25] *Emerging Asia: Challenges and Changes*, Asian Development Bank, 1997.

[26] Cambodia joined ASEAN on 30 April 1999, bringing total membership of the grouping to 10 countries. The RHAP was thus originally endorsed by only nine AMCs.

[27] RETA 5778: *Strengthening the Capacity of the ASEAN to Prevent and Mitigate Transboundary Atmospheric Pollution*.

[28] ADTA INO 2999: *Planning for Fire Prevention and Drought Management*.

CHAPTER 5

Operationalized Regional Haze Action Plan

[This chapter explains the concepts behind the ORHAP and how it is closely linked to, and supportive of, actions at subregional, national, and local levels. Further, the three main program components—protection, mitigation, and monitoring—and the institutional arrangements for the program are discussed in detail with reference to activities falling under each.]

The Process and Considerations

Forests form the main body of the terrestrial ecological system. As an inseparable component of the total land use system, forestry has significant interrelationships with agricultural, pastoral, and food-producing systems. The interrelated and multiple roles of forests, covering the wide spectrum of environmental conservation and use of forest resources, are vital for human welfare and sustainable socioeconomic development.

In planning for forest resource management and development, sustainability is a crucial consideration. And an important component of sustainable management is protection from injurious factors, including fires.

Training of Indonesian firefighters, 1997

Photo: Anonymous

Managing Forest Fires

The importance of fire management is increasing as forests, woodlands, and grasslands face greater demands for commodities and amenities. Recent research has extended our knowledge of fire behavior, fire ecology, fire suppression, and other aspects of fire science that are being incorporated into ecosystem management.

Fire management can take several forms, from no active management to fire exclusion, i.e., total suppression. Fire exclusion may be appropriate for plantations or plant communities of thin-barked trees; while no active fire management may be appropriate for wilderness and national park areas where fire can be allowed to play out its role as a natural disturbance agent; or fire management can take an integrated form. The integrated fire management option embraces all possible treatments, managing ecosystems to enhance the benefits of fire while reducing its detrimental effects (Landsberg 1997, Goldammer 1997a).

Since fire can either be the cause or the result of changes in the landscape, fire management should be conceived on a landscape scale, incorporating forests and their immediate surroundings. Fire management was, and continues to be, largely a reactive process in most developing countries with little data handling capacity (Landsberg 1997). This situation needs to be improved.

Approaches toward fire management will vary for different forests and landscapes, dictated by their characteristics. An essential tool is a fire management plan. This will form part of, or be integrated with, the forest management plan, aiming for sustainability and efficiency. Preparation of fire management plans should be based on statistical and nonstatistical information, including inventory of past forest fires, weather, topography, and fuel type and size, supported by the latest land use and forest cover maps. A classification system and a clear understanding of forest fires and their causes are important to establish alternative approaches to fire prevention as well as for forest rehabilitation. In an integrated approach to fire management, it is necessary to think comprehensively and on a long-term basis, taking into consideration available technology and skills.

Fire Management Planning

Fire management integrates fire-related biological, ecological, physical, and technological information into forest and land management, to meet desired objectives. Interrelated fire management activities include fuel management, fire prevention and control, fire suppression, beneficial uses of fire, and the associated planning, training, education, and research. Fire management, thus, encompasses all measures taken to maintain fire regimes within desired bounds, and is an integrated framework of policies, institutional arrangements, procedures, technology, and resources. This framework usually runs vertically through two or more layers of government, as well as horizontally among various land management agencies and private owners. Fire management policy objectives will not be effectively achieved if any of the pieces of the framework are missing or do not work well together.

Predictability of Future Fires

Economic, social, environmental, and climatic factors have historically been responsible for causing forest and land fires. There is no reason to expect that these factors will become any less responsible for fires in the future. Although forest and land fires are caused by human actions, experience shows that these fires can be primed or aggravated by a prolonged drought (or during ENSOs). The threat of a prolonged drought as well as of forest and land fires can thus be anticipated by regular monitoring of ENSOs.

In areas of recurrent fire and haze, an effective RHAP is needed to prevent them through better management and enforcement. The factors contributing to the starting of fires, particularly weather and related disturbances (e.g., ENSOs), are predictable. Based on data between 1990 and 1997 on the Southern Oscillation Index and sea surface temperature, there will be more *El Niños* in 2000-2003, 2007-2010, 2013-2015, and 2020-2022; or at least two in any 10-year period (MOE-UNDP 1998). Thus, it is possible that fires and widespread haze will occur again, as the present land use plans in the region call for continued large-scale land conversion. There is a pressing need for the region to maintain greater vigilance and to develop better fire management capabilities, well in advance.

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Holistic View of Fire

An event being predictable does not necessarily make planning easy, as it is likely to

> The beneficial role of fire should be an integrated element of the overall approach to sustainable vegetation resource management and protection

be influenced by several other unforeseen situations. A holistic view of fire and an understanding of its negative and positive factors are necessary for intelligent management of resources. Integrated management of fire recognizes its traditional uses and does not exclusively concentrate on fire exclusion (prevention, suppression). The beneficial role of fire should be an integrated element of the overall approach to sustainable vegetation resource management and protection. Also, in order to address the main source of land-use fires, as well as of unwanted wildfires, local people and communities have to be integrated into the overall systems of fire management.

RHAP as a Strategic Guideline

The RHAP document as endorsed by AMMH in December 1997 could correctly be thought of as a set of strategic guidelines that briefly describes the objectives, process, and broad steps to be adopted in this regard. It thus forms the basis for developing an Operationalized Regional Haze Action Plan.

Need for Operationalization of RHAP

When the RHAP was drafted in 1997, the regional fire and haze disaster was at its peak, so crisis management was the order of the day. It was, therefore, not possible to incorporate a great amount of detail concerning how the RHAP was to be implemented. In fact, the RHAP document itself fulfilled a dual function: it provided a mandate for HTTF to take emergency action to address the fire and haze disaster; and it provided a vehicle that ADB could use to quickly mobilize assistance for the RHAP's later implementation via regional and advisory technical assistance.

The process of operationalizing the RHAP has given rise to two versions of the plan. The first version (RHAP) is the one adopted by the nine ASEAN Ministers of Environment when they met in December 1997. This is the formal "official" version, as endorsed by AMMH. The operationalized version drafted by the RETA Project is referred to as the ORHAP.

Principles and Parameters

Any management policy or system should be tailored to certain principles, in order to reflect conditions, needs, and resources. This is particularly true in the case of managing fires.

Some General Principles

Some important parameters are:

(i) know what fire regimes you want: determine what fire regimes are possible under the prevailing climate, ecological conditions, and land use; of these, decide which are most desirable and practicable;

(ii) manage fires to meet specific objectives: these may include sustainable resource management, maintenance of ecological processes or key species, biodiversity conservation, protection of human or natural values, or avoidance of atmospheric or other offsite impacts;

(iii) design fire management policies within the context of other land use trends: as far as possible, address related or underlying factors that increase fire risk; maintain coordination and cooperation with related sectors;

(iv) develop a fire management policy systematically within a comprehensive framework: ad hoc efforts may be needed to address acute fire management deficiencies, but only a comprehensive framework of law, institutions, and resources will be effective in the long term;

(v) involve partners: communities, NGOs, the private sector, and neighboring country governments should be participants in fire policy formulation and fire management. Successful policy formulation depends on asking the right questions of the right people;

(vi) change attitudes: effective fire management requires changing attitudes of key players at the community level, in the private sector, and in the government;

(vii) critically evaluate procedures and technology: imported technology and procedures may not meet needs or may be impractical within resource constraints; and

(viii) assign responsibility clearly (e.g., to the appropriate level of government or community) (Schweithelm 1998b).

Parameters

Three parameters have been identified in operationalizing the RHAP.

(i) The region's transboundary pollution problem is ultimately driven by policy at the national level.

Since land conversion in the ASEAN region over the past two decades has been driven by economic development policies at the national level, there is a direct causal relationship between such policy, land conversion fires, and transboundary haze pollution. This defines an important parameter and constraint within which the ORHAP must pursue its objective of reducing (ideally, to zero) the number, scale, frequency, duration, and negative impacts of transboundary haze pollution in the ASEAN region.

Since this represents an important constraint, it is also an important factor in shaping the framework of the ORHAP.

Land conversion can be carried out in a wide variety of ways, some of which maximize short-term gains at the expense of long-term benefits to the national, regional, or global community. The large-scale land conversion fires that cause haze in the ASEAN region are viewed as being predictable, policy-driven outcomes of the national economic decision-making process. Therefore, these fires will remain a problem in the region until the land conversion process has been completed in all AMCs.

Transboundary pollution is thus seen as a problem that cannot be "fixed," but one that must be managed. The ORHAP must focus on managing the threat of transboundary haze pollution, which will remain a given parameter during the entire period that the land conversion process in the region is underway. It will call for a relatively large number of concrete steps in haze-producing AMCs, supporting and complementing the measures to be carried out at the regional and subregional levels.

> Transboundary pollution is thus seen as a problem that cannot be "fixed," but one that must be managed

(ii) Haze pollution itself results from behavior heavily reinforced by profit considerations.

Open burning as a waste disposal technique is cheap and, therefore, profitable to land users and operators. Land conversion typically involves the felling of trees and clearing of brush. This generally results in a large amount of biomass residue, which in most cases is regarded as waste matter to be disposed via the least-costly and most rapid means—fire. The longer it takes to dispose of the waste biomass, the more profits are reduced.

These considerations have historically made open burning the technique of choice for disposing of waste biomass for small-scale and large-scale land conversion operations. In both cases, the effect is magnified by any direct or indirect subsidies to land conversion.

In the absence of policies that alter the profitability of open burning, either by reducing

Avoiding wastage of resources is the key to the efficiency of the ORHAP

subsidies that encourage it or penalizing this behavior directly, open burning by default will remain the waste residue disposal technique of choice. Modification of this behavior in the short or medium term is a difficult, costly, and uphill task. The ORHAP must, therefore, primarily focus on managing the effects of this behavior, and only secondarily on modifying it, through policies.

(iii) Weather factors increase the tendency of the above two parameters to produce transboundary haze pollution.

As has already been described, the extraordinarily dry conditions brought about by ENSO, among other factors, periodically increase the risk of transboundary haze pollution. This makes the number of measures required for fire and haze prevention, mitigation, and monitoring relatively large, calling for a considerable amount of investment.

Strategic Considerations

Avoiding wastage of resources is the key to the efficiency of the ORHAP. The mix of measures and their implementation must therefore be as cost-effective as possible. Based on the foregoing considerations, certain strategic positions have been identified to ensure that the ORHAP effectively responds to the reality of the situation:

(i) The primary goal of the ORHAP is to prevent the recurrence of transboundary haze and this calls for a focus on fire management.

Preventing transboundary haze requires that the density and quantity of haze in the immediate atmosphere at any one time be reduced below levels that cause haze pollution to cross international boundaries.

(ii) Endorsement of the RHAP/ORHAP by an AMC implies limitations on the manner in which it carries out land conversion.

The limitation to the right of any country endorsing the RHAP/ORHAP to arrange its own natural resource management policy in any way it chooses is that: "it should not allow the haze pollution to emanate from land-conversion fires within its territorial boundaries; and in the event it happens should not allow haze pollution to violate the airspace of another country—thereby causing adverse environmental impact on its own citizenry and those of the neighboring countries."

First, this will require that haze producing AMCs undertake concrete measures to prevent, mitigate, and monitor large-scale fires. A number of related measures must also be implemented at subregional and regional levels.

(iii) In ORHAP, measures that remove or address "binding constraints" on preventing or mitigating transboundary haze pollution will be given highest priority. Measures that address less binding constraints will be assigned lower priority.

The degree to which a measure proposed in the ORHAP will be effective depends on whether or not it would help to remove a cause or a binding constraint, thus reducing the risk of occurrence of fire and haze. For example, if *all* measures under the ORHAP had so far aimed at improving the region's capability to detect large-scale fires, its fire detection capability would be excellent.

But the region's capacity to manage or suppress those fires once detected would be minimal. Taking yet another step to improve the region's capability to detect large-scale fires would have zero impact on improving capacity to prevent or reduce transboundary haze pollution. This is because under such circumstances the "binding constraint" on achieving this goal would be the lack of fire management capacity, not lack of fire detection capability.

The ORHAP so far has led, *in relative terms*, to overinvestment in monitoring and severe underinvestment in fire management and suppression. If this disparity is allowed to widen, the results will be disastrous. This is clearly a suboptimal outcome that can be avoided by adhering to the above strategic principle.

(iv) The purpose of the ORHAP-related measures at the regional and subregional levels is to catalyze and complement—rather than to substitute for—the measures carried out at the national level.

For an ORHAP-related measure to be undertaken at the regional or subregional level, one of the two criteria must be met. The first of these—the economies of scale—should be such that the activity is more efficiently undertaken at the regional or subregional level than at the national level. For example, the division of labor between the regional and subregional level in the training of fire management personnel or in the training of trainers is determined by the nature of economies of scale of the particular training. It is more cost-effective to provide the training of fire management personnel at the regional level than at the subregional level. However, the training-of-trainers in fire management training is more cost-effective at the subregional level or below.

The second criterion is that the measure should catalyze similar measures at the national level. For example, the formulation of an FSMP for the haze-prone areas of Sumatra facilitated by the SRFA-Sumatra is expected to lead to similar plans in other haze-prone provinces of Indonesia.

(v) Wherever alternative measures for achieving the same objective exist, the measure that achieves the desired objective at the least possible cost will be implemented.

The relative scarcity of finances is likely to cause this principle to be upheld in all cases where measures are completely financed by the countries themselves. Special care must be taken also in the case of financing by donors.

Structuring of Programs

For evaluation of impacts/effectiveness, a consistent program structure is needed in which different subprograms, program elements, and projects or activities can be incorporated.

The concept is that the programs and activities are hierarchically linked through a common denominator. In a program structure, the area of concern is divided into several programs; each of the programs into subprograms; each of the subprograms into program elements; and each of the program elements into projects. (If needed, further subdivisions can be introduced along the line of hierarchy. In this hierarchy, the program tends to be long term and projects short term.) Once a project is completed, achieving its immediate objective, it normally is not repeated or continued. It would have, in a short period, contributed to the long-term objective of the program element, subprogram, and program, of which it is a part; and that is the common denominator running through the chain of hierarchy.

Program structure is a form of scientific classification of planned activities for decision making, account keeping, prioritizing, and scheduling. It helps coding of activities and aggregation and computerized data management; it facilitates storage and analysis of trend data, and monitoring and evaluation of programs. A coded structure makes it easy to compile related information.

The designing of program structure should reduce overlaps, improve stability, and simplify future planning, monitoring, and evaluation. The program structures can be developed based

The ORHAP so far has led, in relative terms, to overinvestment in monitoring and severe underinvestment in fire management and suppression

on the nature of activities involved or objectives, or a combination of both. The number of levels in the hierarchy depends on the complexity, size, and spread of the plan.

ORHAP's Program Components

The ORHAP has adopted the three-program structure proposed in the RHAP, of prevention, mitigation, and monitoring.

To effectively address the haze issue requires that several activities and actions are undertaken under each of the three programs to address a particular aspect of the problem. Implementation of each of these actions needs to be monitored closely if the transboundary haze problem is to be properly addressed. In order to keep the cost of monitoring of each action to a minimum, a single agency can be made responsible for ensuring that each action is successfully carried out within the time frame specified.

> In order to keep the cost of monitoring of each of these individual actions to a minimum, a single agency can be made responsible for ensuring that each action is successfully carried out within the time frame specified

The framework of the ORHAP thus works on three levels, the most aggregated of which is that of the ORHAP programs of prevention, mitigation, and monitoring. The next level is that of the activities, each of which fall under one of the three ORHAP programs. The lowest level is that of the actions, each of which supports a particular activity.

Each of these three ORHAP programs is to be operationally defined, by listing the activities that fall under each of them. Once the activities that comprise each of the programs have been decided, the actions that fall under each of the activities are identified. Some of the activities (and the actions under them) are to be undertaken at the regional level, some at the subregional level, and others at the national level.

Program Linkages

Within the framework of a plan, the program components and subcomponents must have vertical linkages (based on the common denominator that links them to achieve program objectives), as well as parallel linkages due to overlapping of scope.

When a plan covers a large spatial area, the space is divided into units and subunits. Each of the subunits and units carries out the program activities, and in aggregation, it adds to the whole. There will be several activities under each of the program areas to be undertaken centrally, covering common areas of interest for reasons of control, guidance, efficiency, effectiveness, and economy. Here also, the linkages—vertical and horizontal—are evident.

For the ORHAP, the ASEAN region has been subdivided into member countries, which each have their own systems of provinces, districts, etc. The NHAPs represent the country plan (including subplans) on fire and haze. The countries are free to adopt their own program structure. The NHAPs are naturally linked to the ORHAP. As in the case of programs, there could also be parallel linkages due to overlapping of interest or other criteria. The two SRFAs (Borneo and Sumatra) within the umbrella of the ORHAP are cases of parallel spatial linkages at subregional level in respect of a program activity, i.e., firefighting.

Thus, the three ORHAP programs have been divided into 20 activity groups—prevention with 10 activities, mitigation with four activities, and monitoring with six activities. (Initially these 20 activities were further subdivided into about 50 specific actions. In the process of refining and revising the ORHAP, the number of activities and actions can change.) Spatially, it consists of nine NFAPs and two SRFAs, appropriately linked.

At the ASEAN level, HTTF will implement activities, monitor progress, and also take action in shaping the region's infrastructure for fire protection and mitigation.

The Planning Horizon

Based on the length of the planning period, the plan can be classified as being immediate term, short term, medium term, and long term. The immediate and short-term plans are operational in orientation and will have detailed scheduling and budgeting of activities and operations. The medium- and long-term plans are of a perspective nature, indicative of the direction toward the goal to be achieved. The plans can be of fixed term, with provision for revision at the end of each period or horizon, each time taking advantage of the lessons learned in the previous period. It can instead be "rolling" in nature, such that it is updated annually or periodically with the horizon remaining unchanged, i.e., there will always be a plan ready for a fixed period ahead. The ORHAP is also designed as a rolling plan with a short-term horizon, being updated annually—i.e., there will be a detailed implementation plan for year one plus a regular ORHAP for the five years beyond (second to the sixth years)—effectively having a horizon of six years.

Thus, the ORHAP is a document meant to be continually refined and updated. Depending on an evaluation of activities conducted/completed during the previous periods, future activities can be modified, new activities added, and redundant ones deleted. These additional activities are expected to be of two types: those undertaken directly by the AMC governments, and those for which donor support will need to be catalyzed.

Hierarchy of Plans

The planned activities will be carried out at regional, subregional, and national (including provincial, district, and village) levels.

National-Level Plans

The ORHAP specifies that all AMCs will formulate NHAPs for combating wildfires and haze, in accordance with their own national priorities and the nature and degree of threat that each faces. It is necessary at every stage to specify operational responsibility and related means and specifications. The actions to be implemented under the NHAPs are a matter for each of the AMCs to decide. This allows for a high degree of specificity in the identification of the actions to be undertaken at national level, and the level of funding devoted. Efficiency demands that the level of investment of each AMC be in direct proportion to the risk of causing or suffering the impacts of fire and haze, this risk being a variable that is likely to change over time.

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Rationale for Subregional and Regional Actions

As already outlined in the section on Strategic Considerations, some actions are such that sufficient economies of scale exist for them to be centralized at the regional level. Other actions are more efficiently undertaken at the subregional level. For example, modeling and forecasting of long-range weather changes such as ENSO requires extensive and sophisticated computing resources. The resources requirement allows it to be most efficiently carried out at a regional level.

On the other hand, sharing of fire suppression resources such as personnel and equipment is more efficiently carried out at the subregional level, since physically redeploying equipment and personnel over long distances is inefficient, impractical, and time-consuming.

Program Description

A detailed treatment of the three ORHAP programs—prevention, mitigation, and monitoring—and the institutional arrangements and instruments required to support effective implementation of the ORHAP, is outlined in the following sections.

Prevention

ORHAP's Prevention Program

In the context of ASEAN-level involvement, the ORHAP has specified 10 activities under its prevention program:

(i) forecasting climatological conditions that are likely to result in fire and haze;

(ii) mapping of areas subject to heightened risk of forest fires, including how these at-risk areas expand or shrink in response to seasonal, annual, or multi-year changes in weather;

(iii) management and dissemination of information relating to the present or likely future fires and haze, the present or likely geographical areas affected by haze resulting from forest fires, and the human health impacts (or likely impacts) of existing or forecasted haze presence or movement;

(iv) reviewing the existing policy framework at the national level with a view to determining how the set of economic incentives that policy framework provides is likely to shape the use of fire as a tool or weapon;

(v) bringing about appropriate policy changes to ensure that the set of economic incentives provided by the policy framework at the national level is consistent with the policy as it pertains to the use of open burning;

(vi) providing market-based and other economic incentives for promoting the adoption of new products and technologies that use biomass and logging or land-clearing residues;

(vii) formulation, operationalization, and implementation of NHAPs that serve as the foundation for operationalizing the RHAP, and increase the degree of readiness to meet forest fire emergencies at the national level;

(viii) harmonizing and integrating the NHAPs at the ASEAN level to ensure their collective consistency and effectiveness in jointly responding to regional forest fires and haze;

(ix) developing and implementing institutional arrangements for linking national firefighting capabilities in any combination within ASEAN (e.g., SRFAs, or other mechanisms for coordinating multiple national firefighting capabilities); and

(x) formulating, ratifying, and implementing an ASEAN-wide Forest Fire Readiness Protocol that formalizes linkages among national-level firefighting capabilities by putting into place a system that enables rapid deployment.

While these activities may not cover all the aspects of "prevention," some of them overlap in certain aspects of mitigation and monitoring, indicating the interrelated nature of the programs.

In the context of the ORHAP, the maximum control of transboundary haze pollution and other related damage (both environmental and material) involves efforts on two fronts

Categorization of Strategic Measures

In the context of the ORHAP, the maximum control of transboundary haze pollution and other related damage (environmental and material) involves efforts on two fronts:

- to prevent fires from outside (e.g., agricultural areas) getting into and burning forests and other natural vegetation, and
- to manage fires that are being set for land clearing and refuse disposal so that the extent and density of burning are controlled.

Fires should be prevented as much as possible. Prevention is one of the most effective ways to tackle land and forest fires, while firefighting is more difficult and costly. Management of land conversion process should be addressed through policies and regulations. The prevention of land and forest fires embraces a wide range of measures that either modify the fuels found within or around the fire-threatened resources to reduce the spread and intensity of fires, or reduce the chances of human-caused ignition.

The various categories of fire prevention measures include scientific resource management, policy reforms/modifications, command and control, public education and awareness creation, and moral suasion. All measures to prevent fire and haze directly or indirectly contribute to mitigation by reducing the intensity of impact, even if fires occur.

Scientific Management of Forest Resource

The traditional approach for preventing fires escaping into forests and to other areas containing large fuel loads has been through a system of fire protection or fire hazard reduction.

Hazard Reduction

Hazard reduction is an important aspect of fire protection. While it is difficult to prevent fires completely, it is possible to reduce fire incidence and intensity. Establishment and maintenance of firebreaks, which are natural or constructed barriers to stop or check fires; clearing the paths, tracks, and campsites of any inflammable materials; planting belts of fire resistant species around parks, protected areas and forest plantations, and along road margins; spraying of fire retardant chemicals in vulnerable locations; establishing buffer zones for protected areas for the dual purpose of fire prevention and habitat protection; and prescribed burning to reduce combustible materials before the onset of the fire season are some of the relevant activities in this regard. In the case of peatswamp forests, hazard reduction should primarily take the form of preventing them from being rendered inflammable by draining.

Prescribed Burning

Prescribed burning, often used as a silvicultural tool, is the controlled application of fire to wildland fuels in specific areas, to promote resource management.

Prescribed burning has been used by foresters, in suitable forest types, to manipulate species composition and characteristics of forests and also to prepare sites for forest plantations. Traditionally, prescribed burns were undertaken after logging to remove branches and other logging debris, expose mineral soil, and produce better growing conditions. However, scientists are now advocating regular prescribed burns to maintain the natural composition of forests, and prevent fuel buildup in forests that traditionally have been visited by fires regularly. According to scientists, if prescribed burns were used more often, then the forests would receive a quick input of nutrients, and excess organic matter would be removed. Such fires in suitable situations can help to check weed growth in forest plantations, induce better regeneration and growth of plants (e.g., teak), maintain a seral status of vegetation that contain a high percentage of commercial species (e.g., moist deciduous forests), reduce soil acidity, increase bacterial activity, and reduce protozoan population (GOI/FAO 1990b).

To accomplish a prescribed burn safely, managers must prepare a plan and instructions detailing how the burn will be executed. A

Scientists are now advocating regular prescribed burns to maintain the natural composition of forests, and prevent fuel buildup in forests that traditionally have been visited by fires regularly

BOX 12 Firebreaks and Fuelbreaks

Construction of firebreaks and fuelbreaks around and inside a forest is a common method employed to interrupt the continuity of fuels.

Firebreaks

A firebreak is a line, up to several meters wide, on which all combustibles are removed and the mineral soil exposed. The objective of firebreak construction is to segregate, stop, and control the spread of a wildfire. The width of the firebreak varies with fuel loads and expected spotting (fires jumping over the firebreak) behavior. Since fires may easily cross firebreaks of up to several dozen meters, their use is not always cost-effective. In addition, firebreaks in steep terrain tend to erode during the rainy season.

Fuelbreaks

The concept of fuelbreaks is entirely different. Fuelbreaks are generally wide (20-30 m) strips of land on which the native flammable vegetation has been modified or replaced by introduced vegetation so that fires burning into them can be more readily controlled. In the tropics, it has been demonstrated successfully that fuelbreaks can be maintained economically by agricultural or agroforestry land uses (e.g., cultivation of groundnuts, millet and legumes, as practiced in Sudan). Fuelbreaks include:

- agricultural and pastoral land uses where most of the woody, aboveground biomass is removed and substituted with agricultural crops and livestock grazing;
- shaded, agroforestry-style fuelbreaks where trees are widely spaced and livestock grazing reduces the abundance of surface and aerial fuels; and
- fuelbreaks that are maintained as forest but where aerial fuels are mechanically shredded or removed.

The most important fuels in forests that need to be treated are those between the ground surface and the canopy of upperstory trees. Surface fuels (grass-herb stratum, shrubs) are the main carriers of fire, while aerial fuels are those combustibles not in direct contact with the ground (foliage, lianas, twigs, understory tree crowns), which carry the fire into the crowns (fuel ladders).

Source: *Tropical Forest Update* 6(1), March 1996.

prescribed burn will be safer and more successful if the perimeter of the area is extended to natural boundaries such as lakes, rivers, and marshes.

Narrow roads or single-blade bulldozed firelines may not be wide enough to prevent the fire from crossing. Along with prescribed burning in the forests, zero-burning methods of site preparation for commercial crops in private lands adjoining forests are often promoted.

> Along with prescribed burning in the forests, zero-burning methods of site preparation for commercial crops in private lands adjoining forests are often promoted

System of Vigilance

In combination with management measures, it is necessary to adopt a system of vigilance and this includes hazard rating, forecasting of fire proneness based on weather pattern and climatic factors, fire risk assessment, fire classification, mapping of fire risk areas, dissemination of fire information, early fire danger warning, intensive surveillance, code of public behavior in high fire risk situation, enforcement of government regulations, and relevant command-and-control measures. Some of these overlap with mitigation and monitoring activities.

Forest fire prevention should be undertaken as a joint effort of all concerned—as a matter of civil defense involving government institutions, private agencies, and the public. Participation of rural people, and their goodwill, is particularly important. It is necessary to provide appropriate incentives for their sustained cooperation.

Establishment and maintenance of firebreaks and other fire prevention and presuppression measures (see Box 12), including the related infrastructure, involve considerable investment. This is often not supplied by individual owners and private companies, to save on costs. During the 1997-1998 fire season in Indonesia, there were no effective firebreak systems in most cases. Even though fire warning messages and related instructions were announced through the media, these were of limited value in the absence of an adequate infrastructure and enforcement system.

Policy Measures

A good policy provides a rational and balanced strategy for action. It helps to prioritize action and to attract funds and attention for carrying out policy components. Policies in general should be able to curtail conflicts and inefficiencies.

A detailed account of policies, strategies, and legal or regulatory instruments has been provided under the section on strengthening of institutions (page 152). Only policy aspects as they relate to the program of protection under the ORHAP are discussed here.

Policies relating to several sectors such as agriculture and rural development directly influence the fire and haze situation. For each of the policy objectives, appropriate measures are clearly to be specified. If the statement of policy objectives and details of policy measures are left vague, there can be serious problems.

Influence of Existing Land Conversion Policy

Land conversion takes place in the major haze source countries, particularly in Indonesia, for raising palm oil plantations, timber estates, expansion of agricultural crops in peatland, and for transmigration. Policies on land conversion, particularly relating to authorized practices, are vague and not supported by stringent and practical control measures. Policies, including instruments available (and employed) for their implementation, indirectly influence human attitudes and behavior. Thus, skewed economic incentives can do more harm than good. Some governments in the region inadvertently increase fire hazards through policies that explicitly or implicitly encourage settlement and conversion of forests because of the incentives provided.

This is particularly true in cases where the overall impact of the country's natural resource management policy is to significantly reward land conversion (and thus large-scale open burning) via financial inducements. The extent of the fire and haze problem appears to be in direct proportion to the magnitude of the financial incentives for land-clearing offered by the policy regime. The greater the financial incentives to clear land the more uphill the task will be to address the issues related to forest fires and haze.

This situation persists due to conflicts among, or inefficiencies within, key aspects of the overall policy framework. The conflicts and inefficiencies embody inconsistencies among policies, such as those of plantation establishment, food security, forest concessions, processing of timber and NWFPs, forest products trade, transmigration, and land-tenure rights of traditional and indigenous groups. A considerable amount of anecdotal evidence exists to show that policy inefficiencies and inconsistencies drive a significant portion of ASEAN's transboundary haze pollution problem.

> Policy inefficiencies and inconsistencies drive a significant portion of ASEAN's transboundary haze pollution problem

Concealed Subsidies

Clearing land of vegetative growth, residues, and debris by burning is the cheapest method, compared to other alternatives. The costliness of other methods (e.g., mechanical, zero-burn system) of land clearance has historically made open burning the technique of choice for disposing of biomass residue. Thus, there is a component of concealed subsidy in the system of land clearance existing in some AMCs.

Ways to discourage land clearing include making open burning expensive by charging fees for a fire license (as with the fire permit system in Malaysia), and requiring landholders to use only controlled burning. Incentives for fire use should be appropriately balanced by disincentives (economic or punitive) for carelessness. It is often carelessness that causes even small fires to go out of control and spread. The right to convert land should not be taken as an unconditional reward and license to cause social harm. Equally important are laws, rules, and

It is often carelessness that causes even small fires to go out of control and spread

regulations pertaining to fires (e.g., forbidding certain activities during summer, in areas prone to fire damage) and their enforcement. They must serve as deterrent for those who commit environmental crimes, while providing incentives to those who cooperate in preventing forest fires.

Changing the Policy Environment

Policies on the use of fire should meet resource management objectives, within the parameters of specific fire regimes. Resource management objectives and fire regimes are likely to change, sometimes quickly and dramatically, in response to alterations in the natural environment or in the social, economic, and political conditions. Policymakers and planners should understand these changes and their impact, in order to design policy instruments that are flexible enough to be effective in a wide range of circumstances.

The Human Context

The nations of Southeast Asia are, with two or three exceptions, in the early to middle stages of economic development. While they vary greatly in terms of culture, economy, political systems, and demography, most AMCs share characteristics that make it technically difficult or politically unattractive for them to manage the human factor in fires. Some AMCs have rapidly growing populations, with a large percentage of poor people living in rural areas who are heavily dependent on small-scale agriculture and forest products for their livelihoods. In some countries, forested areas are resource frontiers for timber production, mining, and commercial agriculture, as well as safety valves to relieve population pressure elsewhere. This has created a three-way conflict between logging and mining firms, agricultural settlers, and indigenous forest dwellers. Governments have frequently been ineffective in reducing the conflicts regarding land and forest resources due to inappropriate or ineffective land use and land tenure policies, insufficient management resources, and often a lack of political will.

In recent decades, this situation has led to faster deforestation, relentlessly changing fire regimes. Poor harvesting practices have made forests more fire-prone, fire use is undisciplined, and fire is often the tool of choice for forest conversion. The changes in the fire regimes of the tropical rain forests has been most dramatic; but even the fire regimes in seasonally dry areas have changed as fires have become more frequent and intense. Policies should now be designed to stabilize fire regimes, a more complex task than managing fires in a relatively stable regime.

The Ecological Context

The climatic and ecological factors that shape fire regimes are generally thought to be relatively stable, but they can change unpredictably and sometimes suddenly. The increased severity of ENSO-related drought in the western Pacific during the last two decades is an example. This may be a short-term anomaly or a long-term trend caused by natural climate oscillations or human-induced climate change. Fire regimes can also change suddenly as the result of natural disasters such as cyclones, which can alter forest structure and fuel conditions overnight.

Each vegetation formation has a characteristic fire regime shaped by climate, ecological factors, and human actions, which determine the frequency, intensity, size, seasonality, and predictability of fire (Christensen 1993). Fire regimes determine how fires affect vegetation ecology and biogeochemical processes and fluctuate naturally in response to long-term climate change and shorter-term climate oscillations. Humans have altered the fire regimes of most areas of the region through their use of fire and modifications of vegetation.

The flora of most seasonally dry areas have evolved in areas where wildfires are frequent, and many species depend on fire for regeneration. In the wet tropics too, flora have evolved in area where fires were caused by severe droughts with long return periods (Goldammer and Seibert 1990). These fire regimes have been altered dramatically over the past century as humans have used fire and harvesting to modify rain forests at an accelerating rate, causing shifts in vegetation structure and species composition.

Policy-Related Suggestions

Lack of a fire policy adds to conflicts and confusion regarding the managed use of fire. Enforcement of fire prevention and control calls for strict policies and rules on burning, including conditions under which the use of fire is legal. Effective enforcement requires a policing system and the political will to act.

The forest fires and haze issue has to be rationally approached through a combination of appropriate policy changes, involving incentives and market-based instruments.

Policy Changes

New policies should primarily aim at altering land clearance practices that cause transboundary haze pollution.

Policies on land use and land conversion practices should define controls relating to type of land, processes, precautions, and social responsibilities. They should promote policy-induced actions, e.g., use of zero-burn land-clearing techniques, and the introduction of fire permits for open burning. Some countries such as Malaysia have introduced such measures. There is evidence that at least under some conditions, zero-burn techniques can be used for disposing of biomass residue from land clearings, with the residue being used for the production of semifinished or finished goods. When properly carried out, such policy measures can help reduce transboundary haze pollution, enhance the environment, and promote economic development.

Supplementary provisions that would help in the prevention of fires and haze include measures to (i) reduce the rate of conversion of natural forests, (ii) reduce the size of forest utilization concessions, (iii) introduce reduced-impact logging practices, (iv) introduce market-based instruments to promote residue utilization, and (v) rationalize shifting cultivation.

In the case of Indonesia, there are some special needs to combat the danger of fires and haze.

- Efforts should be made to provide the capacity and facilities to complete provincial spatial plans to be used as a basis for reliable local land zoning.
- Clearance of peatlands should be subject to special regulations; burning of any kind, including managed burning, should be strictly prohibited.
- All peat soils should be identified and delineated, to ensure special attention and protection.
- Efforts should be made to rehabilitate peatlands that were cleared for irrigated rice planting under the Grand Million Hectare Peatland Project.

Rational Incentives

Instead of allowing undeserved gains through indiscriminate use of fire for land clearing, rational incentives must be introduced, in the interests of sustainable development, social equity, and safety. An example is the no-fire-

Lack of a fire policy adds to conflicts and confusion regarding the managed use of fire

Market-based instruments can be included in a program of waste reduction and waste utilization, incorporating logging residues from neighboring areas

bonus plan of the Philippines, which is an effective fire prevention mechanism within the Social Reforms Agenda of the Mountain Province. In relevant cases, eco-labeling requirements and certification of forest products can be linked to the track record of producers in carrying out forest fire protection measures.

Fire Protection as a Sustainability Criterion

Recently, the concept of criteria and indicators (C&I) in the context of sustainable forest management (SFM) has added a new dimension to strategic planning. C&I provide standards to judge the performance and progress toward achieving SFM. The quality and effectiveness of fire protection should be established as one of the criteria for SFM. An explicit policy statement to that end can help to promote fire protection.

Residue Utilization

There is considerable scope for introducing eco-friendly market-based instruments as effective incentives to adopt zero-burn land-clearing techniques in AMCs. Land-clearing residues can be used (rather than burning them) to produce a large number of intermediate or final products including furniture, fence posts, handicrafts, fuelwood, active carbon, chips for pulping, mulching materials, and other consumer products.

Market-based instruments can be included in a program of waste reduction and waste utilization, incorporating logging residues from the neighboring areas.

A survey conducted under the ADB ADTA[29] in Indonesia showed that the amount of residue in logged forest in East Kalimantan was 419 m^3/ha, including 146 m^3/ha suitable for sawlogs. In Riau, the figure was 98 m^3/ha. In conversion forest, using a cutting limit $\geq$30 cm diameter at breast height (dbh), the wood residue in East Kalimantan was 317 m^3/ha including 177 m^3/ha suitable for sawlogs, while in Riau, the figure was 267 m^3/ha. In areas using less than 30 cm dbh as the cutting limit, the amount of wood residue in East Kalimantan was 29 m^3/ha, while in Riau, little residue remained. Wood residue utilization is limited, as it is illegal to remove any residue from forest concession areas. The main consumers of wood residue in Riau are the pulp and paper industries that consume about half of the residue generated. In East Kalimantan, the residue is still unutilized. The pulp and paper industries in East Kalimantan use their own wood from forest industrial plantations.

While the potential for residue utilization seems to exist, considerable planning and promotion are needed. If residue utilization along with zero-burn techniques of land clearing were to become profitable, it could not only generate attractive incomes to the operator but could even subsidize the mechanical clearing of land. Introduction of a penalty (or high fees) for land clearing by open burning could improve the attractiveness of residue utilization. Any policy that promotes such a system will become a market-based instrument.[30]

The success of market-based instruments depends on the profitability of mechanical land clearing for residue utilization compared to waste disposal by open burning. This relative profitability heavily depends on the degree to which open burning is either explicitly or implicitly subsidized by existing distortions in natural resource management policy in general, and land conversion policy in particular. Other factors such as geographic proximity to biomass residue processing facilities and availability or quality of transport also affect the costs of processing biomass residue. Residue-based products, by their nature, will be of low-value-per-unit-weight, so a wide range of factors would affect their relative profitability.

Zero-Burn Land Clearing and Market-Based Instruments

ADB's RETA Project studied the potential of promoting mechanical land clearing and marketing of products based on residues.

The technical feasibility of zero-burn land-clearing methods has been proven and demonstrated in a number of cases in the region.[31] In Sarawak, Malaysia, land clearance for cultivation is mostly carried out mechanically and land preparation for planting follows "zero-burn" methods. Logs are stacked along contours, to prevent soil erosion. Sometimes a partial/light burning is carried out to reduce the debris.

The exact extent and conditions under which zero-burn land-clearing techniques are financially feasible or applicable are not yet known. However, evidence available so far, suggests that these conditions are likely to vary widely.

What is certain is that in some haze-producing AMCs, explicit and implicit subsidies for land clearance reward the use of open burning. For environmentally conscious operators, existing indirect subsidies act as a strong disincentive to use zero-burn methods. The perverse incentive system, thus, subsidizes the behavior that contributes to transboundary haze pollution and penalizes the behavior that attempts to prevent it. Use of some form of market-based instrument will at least partially remove the two-edged bias against the use of mechanical land clearing.

The Rationale

The rationale for applying market-based instruments to zero-burn land clearing is as follows. Persons using fire as a land-clearing tool enjoy all the profit of doing so, but bear only a small portion of the costs, as populations suffering haze shoulder the rest of the costs. On the other hand, operators using mechanical land-clearing techniques bear *all* of the costs of land clearing. Thus, even if open burning was not subsidized, the operator using open burning enjoys a distinct profit advantage over the operator using mechanical land clearing. Allowing this difference is inconsistent with economic efficiency and market principles under which producers compete with one another on an *equal footing* so that society may enjoy their products at the lowest possible cost. If for any reason, this *equal footing* is weakened or destroyed, society-at-large is the loser. The introduction of market-based instruments promotes competition on an *equal footing* and results in economic efficiency.

Even if open burning was not subsidized, the operator using open burning enjoys a distinct profit advantage over the operator using mechanical land clearing

ADB's RETA Project points out that several firms have successfully completed the transition to mechanical land clearing. The firms that were the most successful in this regard were those that could profitably make use of waste biomass residue either within the firm itself or within a vertically-integrated corporate structure of which the firm formed one part.

The most common and profitable uses of biomass residue were found to be: (i) chipped biomass residue as fuel for steam turbines that drive electricity generators at large, export-oriented pulp mills; and (ii) as a source nutrient for oil palm. In the latter case, the biomass residue was simply allowed to decompose in place. By adjusting the planting time of the oil palm seedlings, the firm was able to significantly reduce application of supplementary fertilizer, resulting in lower production costs.

Some Variants

There are several types of market-based instrument.

System of Cess and Performance Bond

The variant of market-based instrument recommended for encouraging zero-burn land preparation is the cess. The cess, which ideally would represent the financial equivalent of the environmental damage caused by land clearing through open burning, would be collected from *all* persons in advance of land-clearing activities (i.e., when land-clearing rights are granted). The proceeds of the cess would then be held as a performance bond, which would be returned (with interest) to operators who have cleared the plot of land in question via mechanical means. The proceeds forfeited could be used to further improve and promote the mechanical clearing of land.

This arrangement has several advantages. First, it creates a favorable bias toward use of zero-burn techniques for land clearing and land uses that do not require heavy land preparation. While this market-based instrument can be employed even in the absence of policy changes, in practical terms, it would call for appropriate policy direction. The policies should signal a government's intent to encourage environmentally responsible behavior and to discourage the opposite. Second, in cases in which mechanical land clearing is not financially viable, the government will have placed a transparent monetary value on the damage caused to society by open burning, with the compensation being collected in advance of the damage. Third, this sets the stage for tighter environmental controls, once enforcement capacity has been upgraded, or medium-term changes in natural resource management policy have been put into place.

> The cess, which ideally would represent the financial equivalent of the environmental damage caused by land clearing through open burning, would be collected from *all* persons in advance of land-clearing activities

Encourage use of Biomass Residue. A complementary aspect of the market-based instrument is promoting the production and sale of products that use biomass residue as raw material. The forfeited proceeds of performance bonds can be used to subsidize companies that produce goods from biomass residue. This subsidy could be paid in any of a number of ways (e.g., as a year-end corporate tax rebate).

The appropriate level of the subsidy and means of paying it are heavily dependent on the local conditions, the infrastructural facilities available, or the geographical area in which production of the goods using biomass occurs.

Tradable Permits

Making the firms pay for the right to use the atmosphere to dispose off pollutants gives them the incentive to reduce the amount of pollutants. This can be done in various ways. One such variation is tradable permits. The original concept of a tradable industrial pollution permit recognized that it is cheaper for some firms to reduce emissions of certain pollutants than it is for others. Tradable pollution permits are simply "bearer certificates" that grant a limited right to discharge emissions into the atmosphere. The government can then control the amount of pollutants released by limiting the number of certificates issued.

There are several considerations when adapting the tradable permit system to help combat fires and haze: (i) the sources of emission move around and cause a problem in spatial distribution, and (ii) fire and haze are mainly produced during the dry season making it difficult to space out the emission time-wise. Therefore, modifications are necessary if tradable permits are to help reduce haze. One way is to reduce the number of permits in circulation such that a worst case scenario would not cause transboundary pollution.

Direct Pollution Charges

Another market-based instrument for discouraging open burning is the levying of a direct charge for each unit of emissions produced. Conceptually, this is a compelling idea, primarily because firms would be charged directly for the pollution damage they cause, thus forcing them to incorporate this factor into their decision-making process. A variation is scaled pollution charges where polluters pay according to the degree to which they increase the risk of transboundary haze.

But direct pollution charges have drawbacks, most of which result from the fact that government monitoring and surveillance costs are significant. It is probably not feasible to charge directly for the emissions themselves, since this would involve numerous problems in measurement, all of which could be subject to legal challenge.

Recommended Alternative

As with all market-based instruments, the objective of the three types considered—performance bonds, tradable permits, and direct and scaled pollution charges—is to make a particular market function more efficiently, or to create a market where none existed before. The market in question here concerns the rights to use the atmosphere for waste disposal.

Their use would depend on the situation in the jurisdiction in question. All the alternatives have advantages and limitations and it is necessary to balance them. However, based on the situation in Riau and South Sumatra provinces, performance bond schemes have been found to be objective, uncomplicated, inexpensive, and easy to administer. The assumption is that all persons or firms clearing land will do so via open burning. They are therefore charged a fee that reflects the damage that such open burning causes. The fee is then only returned upon the person or firm demonstrating to the satisfaction of the enforcing agency that their plot of land was cleared using mechanical means instead of open burning.

AMCs can collaborate at the regional and subregional levels to support use of market-based instruments at national level. An important prerequisite for the success of market-based instruments at the national level is sustained political will.

For example, implementing a system of performance bonds assumes that the bond will be collected in an efficient and timely manner, and that the proceeds will be utilized in a way that ensures effective functioning of the instrument. Lapses will lead to failure of the instrument to achieve its objectives.

> AMCs can collaborate at the regional and subregional levels to support use of the market-based instruments at national level

Command-and-Control

Command-and-control is an expression to cover all legal measures including instruments, regulatory mechanisms, legal sanctions, and restrictions. Legal measures form an important aspect of fire prevention.

Command-and-control measures directly regulate the use of fire by imposing sanctions against those who use it in unapproved ways. They are therefore usable only at the national or subnational level (nonnational entities can support implementation of command and control measures at the national or subnational level).

A wide range of command-and-control measures exists. The most stringent for fire management is a total ban on open burning of any type under any circumstance. Examples of less stringent command-and-control measures (in descending order of stringency) are:

(a) issuing permits on a case-by-case basis that allow open burning as an exception to a total ban on burning;

(b) automatic issuance of a single-use permit as per (a) above upon the applicant's signing a sworn affidavit that he/she will

In the absence of credible enforcement, stringent measures will *increase*, rather than decrease, the prevalence of open burning

adhere to guidelines specified by authorities;

(c) legal sanctions against persons who do not comply with published restrictions on open burning issued by appropriate authorities;

(d) legal sanctions against persons who do not comply with published restrictions on open burning issued by appropriate authorities during publicly-announced periods of increased fire risk;

(e) limitations on open burning during certain hours of the day, days of the week, or seasons of the year;

(f) bans on open burning unless appropriate authorities are notified in advance of the intention to burn;

(g) restrictions on the area of land that may be burned on any one occasion; and

(h) voluntary compliance with guidelines on open burning issued by appropriate authorities.

The number of permutations and combinations of command-and-control measures regulating use of fire is obviously large. The list of measures above is therefore not meant to be exhaustive. Its purpose is to demonstrate the wide array of the types and levels of stringency that could potentially be adopted by fire control authorities at the national or subnational level.

The level of stringency of the particular command-and-control measure(s) adopted should be consistent with two factors. These are (i) the risk of large-scale fires and haze being caused; and (ii) a realistic assessment of the institutional capacity for implementation of, and the amount of resources available for, enforcement.

Need for Credibility

In the absence of credible enforcement, stringent measures will *increase*, rather than decrease, the prevalence of open burning. Adopting a regime of obviously unenforceable command-and-control measures would cause perpetrators to question whether authorities would *ever* be able to implement *any* fire control regime. If the answer is perceived to be in the negative, the jurisdiction would become an "outlaw area" within which perpetrators could use fire in any manner they like, with impunity.

Even if a regime of strictly voluntary compliance had no more than a neutral impact on the use of fire, it would still be more cost-effective than (and therefore preferable to) adopting stringent measures that the authorities are incapable of enforcing. Further, a credible program of strictly voluntary compliance could comprise the first stage of introducing a phased program of successively more stringent command-and-control measures. If authorities publicly announced their schedule for the phased program in advance, any credibility achieved in the first stage of voluntary compliance would increase the chance of success of more stringent measures later in the program.

The greater the number of phases of the program that have been successfully and credibly implemented, the greater the likelihood of automatic compliance in the future. Such a program thus becomes increasingly more cost-effective over time.

The ORHAP recognizes the legitimacy of all of the command-and-control measures listed previously, as well as their permutations and combinations. It encourages all ASEAN governments to adopt such measures that can most cost-effectively prevent transboundary haze pollution. Ultimately, success at any level will generally depend on:

(i) the political will of the government to enforce the regime;

(ii) the amount of resources devoted to enforcement; and

(iii) the magnitude of surveillance and enforcement costs, which are influenced by the total area of land in which open burning is likely to take place, and the remoteness or accessibility of the areas in which enforcement operations are to be carried out.

Need to Upgrade Command-and-Control Regimes

If an AMC has been a source of transboundary haze over the past 20 years, its prevention efforts could probably be improved by establishing or upgrading existing command-and-control measures on the use of fire. The ORHAP, therefore, has incorporated the procedure described below for this purpose.

Procedure

First, each national or subnational government (as appropriate) should review its current (if any) command-and-control measures. The purpose is to discover how an existing command-and-control regime might be altered (or a proposed regime appropriately configured) to ensure maximum impact per unit of investment in controlling transboundary haze pollution. The criteria established for determining whether or not a particular measure should be implemented at all, and for determining the order of priority for measures contemplated, should guide this process.

Second, all contemplated changes to the command-and-control regime (or measures proposed for a new regime) should be imposed within a time-bound plan for upgrading (or establishing) the regime—for example, with a horizon of not more than five years. Utmost care should be taken in addressing the twin issues of sequencing and timing in formulating this plan. The plan should also include a schedule of estimated costs for the upgrading (or establishment of) the regime, and a description of how these are to be financed.

It is unrealistic to expect that command-and-control measures, in isolation, will be sufficient to control the use of fire enough to prevent transboundary haze pollution. Upgrades should therefore be placed in the wider context of an overall fire and haze prevention program that incorporates policy reforms, moral suasion, and public education.

Regional and Subregional Support

Even though command-and-control measures are to be applied at the national and subnational levels, the ORHAP includes concrete steps to be taken at the regional and subregional levels to support the upgrading (or establishing) of command-and-control regimes in haze-producing countries. These steps include (i) convening workshops so that countries that have successfully upgraded their command-and-control regimes can share the results with other countries contemplating or undergoing such upgrading, (ii) provision or sharing of expertise that directly supports the upgrading process by AMCs that have already completed the upgrading, (iii) assistance in procuring third-party financing for the formulation of such programs, and (iv) catalyzing third-party financing for upgrading command-and-control regimes that have already been formulated.

> If an AMC has been a source of transboundary haze over the past 20 years, its prevention efforts could probably be improved by establishing or upgrading existing command-and-control measures on the use of fire

Moral Suasion

The term "moral suasion" is generally used by economists and other social scientists to denote an attempt to get a private decision maker to incorporate the full costs of a particular action into the decision-making process, as opposed to considering only the direct costs of that action. In the context of the ORHAP, the scope of moral suasion is restricted to influencing the

Moral suasion encourages those who might set large-scale fires to consider all the social costs

decision whether or not to set large-scale fires. Moral suasion encourages those who might set large-scale fires to consider all the social costs (to all populations at home and abroad). Moral suasion may or may not involve an open or implied threat of imposing penalties, should an environmentally irresponsible action be taken. It is generally more effective when it incorporates such a threat and, in effect, complements command-and-control.

During the past two decades, moral suasion has successfully been used to encourage environmentally responsible behavior among the private sector in a large and growing number of countries, including jurisdictions lacking environmental controls, laws, or regulations of any type. The ORHAP has endorsed the use of moral suasion as a category of measures for preventing transboundary haze pollution. As such, it recognizes that moral suasion may be applied by virtually any segment of ASEAN, including the general public, local communities, NGOs, religious groups, and the governments, as well as by international donors.

Means of Moral Suasion

Effective moral suasion can be achieved by ensuring that information on fires and haze is accurately and objectively provided to the public. This is being carried out via the fire-and-haze information management system at the ASEAN Secretariat in Jakarta. This system, which functions as a clearinghouse for fire-and-haze-related information, has been upgraded and a public-access web site established on the Internet.

Because moral suasion initiatives may be undertaken by such a wide range of individuals or groups, there is substantial potential for—and few constraints facing—their implementation at the regional, subregional, national, or other levels. The ORHAP supports all legitimate moral suasion activities implemented at all levels aimed at preventing transboundary haze pollution, provided that these are carried out in ways consistent with the respective legal systems.

Public education through information dissemination is an important means of moral suasion.

Public Education

The fire-and-haze information management system at the ASEAN Secretariat, and in particular, its web site, functions as a public education and awareness-raising vehicle. The more informed the people are on fire and haze issues, the more likely it is that they can express their feelings on transboundary haze to the appropriate authorities; or to engage in moral suasion. The ASEAN community has an intrinsic right to as much information as available on forest fires because of the profound and wide-ranging impacts of transboundary haze pollution.

An important function of public education is to ensure that the public is made aware of the health risks associated with exposure to haze pollution, and of the preventive measures that individuals need to take to minimize these risks in the event of haze. The ORHAP includes numerous initiatives for disseminating information regarding fires and transboundary haze to local communities in more remote areas as well as those in urban centers. The system also incorporates measures to inform regional and international bodies of the steps being taken within and beyond the ASEAN jurisdiction to prevent and mitigate large-scale fires and transboundary haze pollution.

Public education and awareness programs are most effective (and cost-effective) when formulated and implemented at the community level. As FSMP is a community-level response to the threat of forest fires and haze, HTTF decided that the plan should incorporate public education.

Within the ORHAP, the public education measures that should be given the highest priority are those that are the most cost-effective. There are two factors that affect the cost-effectiveness of these measures: first, the greatest impact per unit of expenditure, when they are implemented within the context of an overall plan; and second, capacity to generate revenue.

Public education initiatives that generate revenue tend to be more cost-effective (and sustainable over time) than those that do not. ASEAN's fire-and-transboundary-haze-pollution problem is of such high profile that opportunities exist for tied-in revenue-generating public education initiatives. Such opportunities should not be overlooked because of assumptions that public education initiatives can only consume and not generate resources for their further expansion. The fire-and-haze-related public education initiative of the IFFM based in Kalimantan (Indonesia) provides an example. The project has resulted in television shows on the fire-and-transboundary-haze problem featuring an Indonesian teenage television star. This initiative appears to be revenue-generating to the point of profitability. It also gives rise to profit-making spin-off initiatives involving the sale of clothing and other paraphernalia associated with the shows.

Among the issues decision makers and the public need to be informed about are the various alternative methods of land clearing and their implications. To this end, it is necessary to develop and disseminate outreach materials such as posters, pamphlets, and brochures featuring some best examples of land-clearing practices and fire prevention techniques. Moreover, scientific knowledge and information about forest fires should be developed in multimedia format and disseminated through television and radio broadcasts. Development and distribution of short and illustrated summaries of lessons learned in addressing impacts and possible causes of 1997-1998 forest fires will help to make people aware of the disaster and dissuade them from activities damaging the environment.

Strategy for Public Awareness and Education

The development of community and public education programs is seen as the most effective way of creating public awareness on the impacts of fires and haze. Such programs also create a sense of personal responsibility that reduces the likelihood of the occurrence of more large-scale fires in the region.

The ORHAP envisaged the first phase in this regard as the formulation of a regionwide operational strategy for a public awareness and education program. UNEP has provided funds from the public awareness and education component of the Emergency Response project to develop the first phase of the regional strategy. This will focus primarily on the two SRFA pilot areas with possible spin-offs to Brunei Darussalam, Malaysia (particularly the states of Sabah and Sarawak), and Philippines (with emphasis on Palawan). UN-ESCAP has agreed in principle to provide additional support. Once the operational strategy for the public awareness and education program has been formulated and disseminated, it is expected that further support from a wide range of donors can be catalyzed.

Public education initiatives that generate revenue tend to be more cost-effective (and sustainable over time) than those that do not

Mitigation

ORHAP's Mitigation Program

There are four main activities designed to be taken up within the six-year planning period envisaged under the mitigation program of the

ORHAP. These are based on current priorities at ASEAN regional level.

The activities include the following:

(i) formalizing arrangements for improved training and retaining of forest firefighters at the national and regional levels. They should be adequately equipped to cope with future forest fires;

(ii) inventorying existing firefighting capability at the national level, including all aspects of firefighting equipment and personnel. This would determine the maximum scale of a forest fire that the existing firefighting capability is equipped to handle;

(iii) strengthening firefighting capability at the national level to a point at which each AMC's firefighting capability is sufficient to cope with forest fires likely to occur; and

(iv) ensuring the continued readiness of national firefighting through regular maintenance of equipment and upgrading of skills among firefighting personnel.

Haze mitigation is designed to reduce haze and its impact; and fire mitigation aims to reduce the spread and intensity of fires and their impact

Scope of Mitigation Activities

The dictionary meaning of mitigation is "to cause to be less harsh or hostile; to soften; to relieve; to reduce; to mollify." In that general sense, haze mitigation is designed to reduce haze and its impact; and fire mitigation aims to reduce the spread and intensity of fires and their impact. Since haze is an impact of fire, mitigation of haze and fire overlaps.

Mitigation requires action at three stages—pre-event, during event, and post-event. With respect to fire and haze, correspondingly, these three stages are: (i) preparedness for any fire occurrence (in which actions relating to infrastructure, equipment, strategies and/or logistics, training, crew fitness, surveillance, etc., are planned and implemented); (ii) suppression (covering such aspects as fire detection, quick communication of correct information, crew mobilization and dispatch, provision of water, movement of equipment, coordination of field action, e.g., of aerial and ground operations, firefighting, and extinguishing of fire); and (iii) relief (to those who are affected by haze pollution and fire, including medical attention and compensation) and rehabilitation (to repair damage to property and resources).

Along with or immediately after a fire, two different operational directions will be involved—one, to address haze with its transboundary dimension, affecting the health, welfare, and lives of the people; and two, to address the damage by undertaking damage control and rehabilitation (including salvage operations where appropriate).

Mitigation activities are closely linked with other ORHAP programs—prevention (e.g., use of firebreaks, fuel load control, and others) and monitoring (e.g., weather monitoring, fire modeling, fire spotting, and assessment of haze intensity).

Mitigation thus involves a continuum of interrelated activities and in the ORHAP, covers most of the entire spectrum of fire management.

Mitigation and Fire Management

Mitigation is a strategy for suppressing unwanted fires. Fires on the landscape become unwanted when they extend beyond their intended management objective by: (i) placing at risk human health and safety, and valued natural and human-made resources; and (ii) creating haze pollution beyond the boundaries of the area affected by fire. To effectively address the two criteria of unwanted fires, the use of a fire danger rating index and an air quality index is necessary.

Modern fire management recognizes that it is not possible—nor is it always desirable—to extinguish *all* fires. Fire management may therefore involve containing a fire, which is then allowed to burn itself out. If extinguishing a particular fire is feasible and desirable, fire management may involve suppression. At the other end of the spectrum, fire management may involve prescribed burning. This is usually carried out to destroy accumulations of fuel that if left undisturbed could result in fires on a scale large enough to cause heavy damage and/or transboundary haze.

The components that comprise modern fire management are consistent with virtually any policy toward the use of fire. They are as fully consistent with a complete ban on open burning as they are with conditional and controlled burning or voluntary compliance. The approach that a particular AMC takes in its policy toward fire reflects that country's perception of its particular situation (e.g., the extent of forest and wildlands, the degree to which it might contribute to economic growth, and the level of development of the country's fire management infrastructure). In all cases, however, adequate fire management and suppression capability is an obvious requirement.

AMCs that allow open burning, either as a matter of explicit or implicit policy, put the whole region at a higher risk of transboundary haze pollution than do countries that ban open burning. Countries that allow open burning thus have a bigger obligation, for the safety of the rest of ASEAN, to invest appropriately in fire management than countries that ban open burning, other things being equal. This additional investment is necessary to compensate for the increased risk of transboundary haze pollution resulting from their policies. This is particularly true of AMCs in which large-scale land conversion is taking place.

The Different Phases of Fire Management

Fire management covers all aspects and phases relating to land and forest fires. A haze action plan is, in a way, a fire management plan and includes pre-fire (or pre-suppression), suppression, and post-fire (or post-suppression) phases.

Since the pre-fire period is aimed at improving preparedness, the focus of action is to enhance overall fire management capability and to plan for mobilization of all necessary resources for fire suppression in the event of a fire. Thus, this is a vital phase and can conveniently be divided into two subphases: (i) the period of high fire probability and risk, i.e., immediately prior to a likely fire, or a period of high fire danger rating, and (ii) a period of no fire threat, i.e., outside/before the fire danger period.

AMCs that allow open burning, either as a matter of explicit or implicit policy, put the whole region at a higher risk of transboundary haze pollution than do countries that ban open burning

Activities During Periods of No Fire Danger

During the period between two fires, when there is apparently no fire danger, many operations can be carried out, for example:

(i) developing and maintaining infrastructures, water storage, firebreaks and fire corridors, aircraft landing sites, etc.;

(ii) acquisition/maintenance and stock verification of tools and equipment (hand tools, heavy equipment, water hoses and tankers, communication equipment, etc.);

(iii) preparing/revising fire maps, information materials, guidelines, and instructions for crew;

(iv) planning for fire emergencies, covering strategies and logistics;

The advent of advanced technology has led to the development of computerized fire management systems that offer the chance to overcome some of the weaknesses in fire management planning

(v) establishing fire detection, surveillance (aerial and ground), and intelligence systems;
(vi) preparing resource mobilization plans;
(vii) contacting community leaders, cooperating agencies, and volunteers;
(viii) conducting training and retraining for various levels;
(ix) reviewing/modifying/improving organizational arrangements, and standby/response orders; and
(x) conducting dry runs and intensive drills, and keeping the crews in good shape.

The activities are carried out as per plan and the purpose is to keep the whole system "well-oiled," and to ensure that no details are overlooked so that "the war is not lost for want of a nail."

Fire Plan

The purpose of forest fire planning is to develop elements of a fire management program and to achieve an adequate level of readiness to attack a major blaze, when it happens, efficiently and effectively. It covers aspects such as hazard reduction, weather monitoring, and capacity development for quick response to fire incidents. It takes into account the engineering, education, and (law) enforcement aspects of fire management.

The advent of advanced technology has led to the development of computerized fire management systems that offer the chance to overcome some of the weaknesses in fire management planning. Along with appropriate models to provide an integrated fire rating scheme, it will be possible to develop an advanced fire suppression strategy by integrating the ground positioning system, GIS, and high resolution remote sensing. A GIS database consisting of elevation, hydrology, geology, vegetation, transport networks, settlements, etc., will be useful in planning fire suppressions and mobilizing resources.

Other strategic elements requiring focused attention include the following:

- measures and actions for the efficient mobilization and dispatching of fire suppression resources and a plan (fire suppression mobilization plan) that can be used to improve the organizational efficiency and cost-effectiveness of fire management at village, district, provincial, national, subregional, or regional levels.
- capacity building programs ranging from training for managers in theoretical and practical aspects (covering forest fire factors, fire prediction and planning, surveillance, fire protection, fire suppression, rescue operations, and rehabilitation) to practical drills in fire suppression for firefighters. Appropriate training is also required for local volunteers and others who will be required to participate in firefighting;
- arrangements for the provision of vital information including checklists, maps, etc.; and
- appropriate mechanisms to obtain participation/cooperation of local people, communities, the private sector, and NGOs in fire management and suppression. Local people can be enlisted as voluntary fire wardens and voluntary firefighters. Improved incentives including honorariums, access to resources and entrepreneurial opportunities, and provision of off-farm income-earning to community members will help to promote participation.

Procedure for Activating Firefighting Resources

The centerpiece of the mitigation program of the ORHAP is envisioned to be a regionwide fire suppression mobilization (and response) plan. An important first step in formulating the FSMP is to organize a regionwide inventory and assessment of existing firefighting capability (tools, equipment, personnel, level of training, funding, adequacy of existing dispatch plans, and overall capability in responding to fire emergencies) to support cooperative fire suppression efforts. Such inventories should be conducted regularly.

Inventory of Fire Management Capability

Fire management and suppression capability is of prime importance for the ORHAP. If fires and haze in the ASEAN region are to be managed efficiently, then the upgrading of any inadequate fire management capacity must receive high priority. With this in mind, several inventories were undertaken prior to, and during, implementation of ADB's RETA Project.

As the country designated to take the lead in implementing the mitigation program, Indonesia began a preliminary inventory of fire management capacity prior to commencement of the RETA Project. At HTTF's request, Indonesia performed a second inventory with assistance from the Project.

Because the first and second inventories focused mainly on equipment rather than the overall aspects of fire management capacity, the RETA Project itself conducted a third inventory at the request of HTTF, with assistance from the US Forest Service, AusAID, and Canada, and a team of Indonesian experts. The exercise involved four field teams.

The countries included in the third inventory comprised Brunei Darussalam, Indonesia, Malaysia, Philippines, and Singapore. In each of the countries, the inventory and assessment covered equipment, fire management personnel, facilities, communication, logistics, training programs, fire control organizations (national, provincial, community organizations), and operational procedures. Lists of equipment provided details of hand tools, water handling equipment, mechanical equipment, transportation, aerial firefighting capability, personnel protection equipment, logistic support, fire detection tools, and communication equipment.

Three major findings resulted from the inventory and assessment exercise.

First, the level of wildland fire management capacity across AMCs is inversely related to the degree to which each country suffered from forest fires and haze during 1997-1998.

Second, in Indonesia, the AMC most affected by fires and haze, there is a relative scarcity of dedicated fire suppression equipment, but a relative abundance of nondedicated fire suppression equipment (i.e., equipment such as common agricultural tools that can effectively be used for fire suppression). This means that in terms of potential fire suppression capacity, Indonesia is well placed. By effectively organizing its abundant personnel and nondedicated fire suppression equipment, Indonesia can quickly and cost-effectively improve its fire management capacity.

Third, a far greater upgrading of fire suppression equipment and technical expertise than originally envisaged would be required at district level and below, for fire suppression units at these levels to provide the necessary base for regional cooperative fire suppression initiatives.

Fourth, in most of these areas, it is the manner in which fire suppression equipment and personnel is organized—rather than the lack of either—that forms the binding constraint on fire management capacity.

Last, in the absence of operational FSMPs, the region's fire suppression resources tend to be used in a highly inefficient manner.

If fires and haze in the ASEAN region are to be managed efficiently, then the upgrading of any inadequate fire management capacity must receive high priority

A positive aspect to these findings is that in locales in which the region's fire management capacity is wanting, this capacity can be mobilized at low cost, simply by organizing existing fire suppression resources in a more efficient way. This is true of all governmental levels and is the key to ASEAN mobilizing fire suppression resources at the subregional level.

The original intention of the inventory and assessment was to: (i) aggregate data on available equipment and technical expertise, (ii) construct a regional-level inventory and tracking system for fire suppression equipment and personnel, and (iii) construct from this system, an operating procedure for activating forest firefighting resources (Operating Procedure) in the ASEAN region. However, two findings of the inventory and assessment exercise indicated that a different strategy for formulating the Operating Procedure would be required.

- First, the inventory and tracking systems for fire suppression equipment and personnel become unwieldy and unfeasible beyond the district level.
- Second, the existing inventory and tracking systems in the most critical haze-producing areas (Kalimantan and Sumatra in Indonesia) were either at a preliminary stage of development or were nonexistent. Thus, in most critical areas, inventory and tracking systems for fire suppression equipment and personnel would have to be newly arranged, or substantially upgraded, to enable fire management units at these levels to support regional cooperative fire suppression initiatives.

> The Operating Procedure acknowledged that the key to efficient fire management is capacity at the community level, rather than being based on centralized management at the regional level

Architecture of the Operating Procedure

Accordingly, it was decided by HTTF that the Operating Procedure be based on community-level FSMPs, the foundation for which had already been laid by the ADB ADTA.[32] AusAID provided assistance for the formulation of the Operating Procedure.

Essentially, the Operating Procedure acknowledged that the key to efficient fire management is capacity at the community level, rather than being based on centralized management at the regional level. This can be achieved by formulating community-level FSMPs, which would incorporate (ground-based) monitoring activities, as well as fire prevention and awareness programs. They would also serve the additional purpose of providing a framework for upgrading equipment and skills, since only when existing fire suppression resources are organized as efficiently as possible can appropriate upgrading programs be formulated.

The architecture of the Operating Procedure would thus involve a network of interlinked FSMPs at the community, subdistrict, district, province (or state), and national levels in each country. These national networks of FSMPs would then link at the supranational level with AMCs located in the same subregion.

Measure of Adequacy for Fire Management Capacity

The ORHAP requires that each AMC match its fire management and suppression capability to the level of risk of causing transboundary haze. If a particular country has *not* been a source of transboundary haze during the past two decades, its fire management capability at a minimum is considered to match the level of risk to which it exposes the region. It may be that the land conversion process in the country has essentially been completed, reducing the risk of large-scale fires to a minimum.

The fire management capacities of some AMCs fall far short of the required standard.

One purpose of the ORHAP's mitigation program is to outline a system through which these countries can speedily acquire adequate fire management and suppression capacity.

Under the ORHAP, the fact that a country has been a source of transboundary haze during the past two decades is prima facie evidence that its fire management capability falls short of what is required. The ORHAP requires that any such country must, as quickly as possible, create a timebound plan for upgrading its fire management capacity to a level sufficient enough to cope with once-in-20-years fires and haze. The ORHAP further requires that following any fires and haze, the source countries must put in place time-bound operational plans to be able to manage and suppress fires of the scale that caused the haze. Fulfillment of this condition ensures that at a minimum, AMCs have sufficient fire management and suppression capacity to address the risk of transboundary haze to which they may expose the region. Information must be shared with all other AMCs on a continuous basis, either via the ORHAP's restricted-access intranet, or other appropriate means of communication (e.g., facsimile/letter sent to HTTF).

It is, however, by no means certain that any upgraded fire management and suppression capacity in an AMC would be sufficient to successfully address all future threats of transboundary haze. It calls for a system of continuous assessments and upgrades.

Ultimately, upgrading fire management/suppression capacity is a costly venture that must compete with other national priorities. It is therefore not possible—nor does the ORHAP's mitigation component require—that all AMCs build national-level capacities sufficient to completely eliminate the risk of their causing transboundary haze at any point in the future. Instead, AMCs need only fulfill their responsibilities under the ORHAP. Regional-level collective action can, often, compensate for likely deficiencies in individual countries.

In many cases, more than the cost, the binding constraint on efficient fire management and suppression is a cumbersome and inefficient organizational structure, the streamlining of which is nearly costless. Assistance in obtaining the necessary expertise or funding may be requested from the chairperson of HTTF, who channels such requests to the appropriate agencies or institutions. The upgrading of fire management and suppression capability in transboundary-haze-source AMCs is also supported by complementary measures at the regional and subregional levels.

> In many cases, more than the cost, the binding constraint on efficient fire management and suppression is a cumbersome and inefficient organizational structure, the streamlining of which is nearly costless

Upgrading of Fire Management Capacity

Often, upgrading of fire management capacity is taken to be synonymous with procuring additional tools or equipment, or providing additional training or retraining to fire management personnel.

Provision of training and equipment has in the past been popular. But only under restricted conditions have such initiatives had a positive impact on fire management capability. When provided in isolation, training and equipment do little to improve fire management capacity, since lack of training or equipment per se is rarely the binding constraint.

Only when equipment and training are provided to remove binding constraints present in an overall fire management and suppression system are they likely to have any appreciable positive impact.

The equipment procured often fails to reach the hands of those that can most efficiently make use of it, and training is received by those deemed deserving a favor, rather than those who might best benefit from it. Further, the type, scale, size, and level of technical sophistication of the

Equipment procured often fails to reach the hands of those that can most efficiently make use of it, and training is received by those deemed deserving a favor, rather than those who might best benefit from it

equipment procured is often poorly (if at all) suited to the requirements of the recipient country. The same can be true of the type and content of training provided.

Upgrading of fire management capacity is to be undertaken within a system of FSMPs (formulation or upgrading) for specific geographic areas. Such plans are the basic building blocks of fire management capacity.

Fire Suppression Mobilization Plans

The purpose of FMSPs is to improve the efficiency with which fire suppression resources in any given geographic area are mobilized. FSMPs can therefore be used to improve the organizational efficiency and cost-effectiveness of fire management at the village, subdistrict, district, provincial, national, and subregional levels.

Given that FSMPs at the community level were to provide the foundation for ASEAN's fire suppression resource-sharing scheme, they would be linked operationally at community level, and subsequently at higher levels.

FSMP formulation and implementation focus on Indonesia, since the payoff from upgrading fire management capacity in that country outweighs that in other AMCs. Owing to the constraints caused by the recent financial crisis affecting some AMCs, FSMP focuses on consolidating and better organization of existing fire suppression resources, rather than on wholesale additions of fire suppression equipment or training. Only after the existing suppression resources are organized as efficiently as possible would it make sense to shift the focus to upgrading fire management capacity.

Such upgrading programs use the existing FSMP as the starting point, since it is from the FSMPs that the personnel, skills, and equipment requirements can be most easily derived. And it allows the initial and recurrent financial costs of the upgrading to be calculated with reasonable precision, given that FSMP programs already in place include an annual review and budgeting process. If government funding allocated to fire suppression in the area in question is insufficient to finance a proposed upgrading program, then third-party sources of financing have to be sought. Alternatively, the upgrading program can be scaled down, or undertaken in a phased manner over several budgeting periods.

Building on the foundation provided by ADB's ADTA INO 2999, which provided inputs to Indonesia's Integrated Action Plan (IAP) for Addressing Land and Forest Fires, and in order to ensure consistency among the FSMPs at the various governmental levels, a Model Fire Suppression Mobilization Plan was drawn up. This was done by national fire management experts (NFMEs) and numerous international fire management experts working on various projects closely interlinked with, and catalyzed by, ADB's RETA Project and the ORHAP. The model FSMP was then used as a template for developing FSMPs for the most critical areas. The rationale for this is that virtually all jurisdictions, to ensure adequate fire management capacity, should share one factor in common: a preformulated, agreed, written FSMP that embodies the collective decisions of all relevant agencies on how fire emergencies are to be addressed within the geographic area concerned.

Having agreed on FSMPs in advance of a fire allows such incidents to be addressed as quickly and efficiently as possible, *regardless of the extent of financial resources available for addressing the fire emergency.*

For the RETA Project, community-level FSMPs were prepared for critical districts of Riau and South Sumatra provinces, with a view to ultimately replicating them in all critical provinces of Sumatra and all four provinces of Kalimantan.

Salient Features of FSMPs

FSMPs lay out, well in advance, the exact procedures to be followed in carrying out suppression. Therefore, all suppression resources available in the area covered by the plan can be used in as efficient a manner as possible. They avoid spur-of-the-moment crisis-management-oriented decision making, which always leads to inefficient resource use and wastage of valuable time. FSMPs specify a single, transparent chain-of-command for addressing fire emergencies agreed in advance by all parties concerned. This avoids confusion and decisions being taken at different levels that conflict with one another. They provide an organizational structure into which complementary fire suppression resources can be merged. When fire suppression crews from another geographic area or country arrive at a fire scene, these can be deployed immediately and with maximum efficiency.

If a fire escalates to the point where locally available resources can no longer cope, FSMPs state the procedure to be followed. The success of FSMPs, however, depends on sustained commitment—by all parties and agencies that have agreed to participate in the plan—to maintain and enhance the degree of readiness the plan envisages.

FMSPs allow all available resources, including those provided by volunteers and local community groups to be deployed with maximum possible efficiency. In virtually all jurisdictions, volunteers (not to mention donors) are much more likely to participate actively in fire suppression (and prevention) when a plan exists that unambiguously welcomes their role.

Formulation (and implementation) of a FSMP for a specific geographic area can therefore take place independently of any proposed or pending changes in the lead agency for fire management at the national level, or of proposed or pending devolution of powers.

Once an FSMP has been formulated for a particular area, the maximum degree of readiness that can be achieved using available resources can be determined. If a greater degree of readiness is deemed to be required, a program for upgrading the existing degree of readiness can be easily formulated from the plan, and the relevant personnel, training, tool, and equipment requirements derived. From these, reliable cost estimates and a realistic schedule for implementing the upgrading program can be formulated. In extreme situations, FSMPs can be funded entirely at the local level, using whatever financial or other resources are available.

Experiences of the 1997-1998 fires suggest that some of the most efficient fire suppression schemes were funded and implemented totally by local communities, using self-provided resources. The donor-sponsored mobilization plans that operated within the geographic areas adjacent to the project sites enjoyed similar success.

Experiences of the 1997-1998 fires suggest that some of the most efficient fire suppression schemes were funded and implemented totally by local communities, using self-provided resources

The FSMP Process

Details of the procedure for formulating and implementing FSMPs are given in Appendix 3. Only some important aspects relating to the FSMP process are highlighted here.

Initial Planning

FSMPs are to be prepared or upgraded for a sufficient number of geographic areas within the country concerned to ensure that fire management capacity is sufficient to cope with a once-in-20-years occurrence. A work plan for preparing FSMPs is necessary if a time frame (and budget) are to be followed. The work plan should specify that operational training, equipment, and other input requirements are to be collectively derived from the FSMPs; and should consider the potential for, and constraints on, local provision or manufacture of such inputs.

Once the work plan for formulating or upgrading the FSMPs for all geographic areas has been completed, a cost estimate should be prepared. If the number of FSMPs is relatively large, the overall workplan can be divided into phases, with the work being undertaken for groups of geographic areas arranged in order of priority. Higher priority will be assigned to places posing the greatest risk of causing transboundary haze.

A financing plan to meet estimated costs is then prepared; and technical assistance should also be sought from countries well advanced in wildland fire management.

Institutional Collaboration

While preparing FSMPs, every effort should be made to simultaneously create a transparent and operational institutional structure for fire management for the country as a whole. In several countries (including countries highly advanced in fire management) many agencies cooperate in fire management initiatives. But the countries with the most efficient fire management regimes are those that succeed in designating a single body as the lead agency in fire management. The lead agency takes responsibility for working out, in consultation with all agencies involved in fire management, the details of all collaborative working arrangements.

These details, including the roles and responsibilities of each particular agency, should then be enshrined in written interagency agreements. For countries in which the organizational side has previously been the binding constraint on efficient fire management, care is needed in sorting out the institutional details of the new organizational structure and related roles and responsibilities. Successfully concluding such interagency agreements is not a trivial task, as it generally results from negotiations enabling all agencies to arrive at a consensus as to the various roles and responsibilities of each. While somewhat onerous, this task is central to ensuring that later implementation of the FSMP can succeed.

Successfully concluding interagency agreements is not a trivial task, as it generally results from negotiations enabling all agencies to arrive at a consensus as to the various roles and responsibilities of each

Simulation Exercise

Simulation exercises and mock drills are an important part of the process, helping to enhance an FSMP. An example involving a “dry exercise” and “wet exercise” was carried out in Riau province in October 1999, funded by UNEP’s Environment Assessment Programme for Asia Pacific. It was conducted by Indonesian Government agencies connected with fire suppression, with BAPPEDAL acting as the coordinator, in collaboration with the ASEAN Secretariat/CSU.

This joint activity was a part of the Immediate Action Plan—Field Training Exercise Phase 1,[33] which comprises activities not only for mitigation, but includes ones aimed at prevention and monitoring of forest fires and haze in the most haze-prone areas in Riau and South Sumatra provinces.

The objectives of the fire suppression simulation were to create a practice arena for learning and strengthening existing institutional structures involved with fire suppression at the province and district levels. The dry exercise consisted of a “Tactical Exercise without Troops” (TEWT) at the provincial and district levels and the wet exercise consisted of a full-scale drill at four priority districts. The purpose was learning while doing. The observations recorded indicate that there was confusion in the division of responsibilities among national agencies. Institutional weaknesses, including poor coordination, were evident. These need to be addressed in order to enhance FSMPs.

Resource Constraints

The personnel, training, equipment, and other input requirements for particular FSMPs arise as part of the process of preparing or upgrading FSMPs.

Once the input requirements are derived, an inventory of tools, equipment, and skilled personnel for that geographic area should be undertaken, and the results of the inventory compared with the operational requirements of implementing the FSMP concerned. Requirements for additional training, and fire management and communications equipment, are then derived by comparing the overall requirements of the plan with the results of the inventory.

The cost of implementing the FSMP should be kept to a minimum, for example, by using volunteers, labor-intensive fire suppression techniques, and community- or village-level resources wherever possible. Local manufacture of tools and equipment or adaptation of agricultural tools for fire management should become part of the overall plan.

Precise costings for the necessary training and equipment should then be formulated, and a proposed schedule for their provision devised. Funding can be arranged, in part from third-party sources, if necessary. If funds for meeting the training and equipment requirements are insufficient or not forthcoming, the requirements should be reviewed and scaled back, or provision of lower-priority items and training deferred. This should be brought to the notice of HTTF.

Level of Details in FSMPs

FSMPs are the most detailed at the base (i.e., community) level, since it is here that predetermined arrangements for mobilizing and dispatching suppression resources must be specifically stated. When base FSMPs are linked together at successively more aggregated levels of government (subdistrict, district, province, national), the amount of details decreases (with each higher level of aggregation).

FSMPs at the national level generally do little more than indicate the role each national-level agency associated with fire suppression is to play. National-level FSMPs tend to be short, thin documents, while those at the community level tend to be highly detailed. FSMPs at the district and provincial levels simply contain standard operating procedures (SOPs) for sharing of fire suppression resources among subdistricts within a particular district, or districts within a province. District- and provincial-level FSMPs are thus similar in format to those for the SRFAs. SRFA-level FSMPs need not be highly detailed documents, since they essentially comprise interagency agreements specifying the SOPs for activating SRFA-level fire suppression resource-sharing arrangements.

As the process of formulating or upgrading FSMPs is completed for the various areas of the country, a database containing all relevant information such as the training and equipment requirements, the operational costs of implementing the FSMPs, and the inventory of skilled personnel and equipment should be assembled.

This should be performed individually for each geographic area, and the results aggregated at the national level. Updating of this database should be continually carried out. The government agency performing this task at the national level should be assigned the lead role in fire management.

The cost of implementing the FSMP should be kept to a minimum, for example, by using volunteers, labor-intensive fire suppression techniques, and community- or village-level resources wherever possible

Regional or subregional sharing of fire suppression resources is a form of risk-pooling

Subregional Cooperation in Fire Suppression

As outlined earlier, once FSMPs have been formulated and implemented at the community level, they are linked through an FSMP at the district level. District-level FSMPs are likewise linked through an FSMP at the provincial level. For instance, for the fire-prone areas that fall within the jurisdiction of the SRFA for Borneo and Sumatra, the provincial-level FSMPs are linked together through FSMPs at the SRFA level.

Since the subregion is the highest level of aggregation at which economies of scale in fire suppression activities exist, this interlinkage of FSMPs does not extend to the regional (i.e., ASEAN) level.

Rationale for Subregional Cooperation

The main rationale for subregional cooperation in fire management and suppression is its cost-effectiveness. One means of increasing this is via risk-pooling at international level. This involves supranational sharing of fire suppression resources during periods of peak demand.

Regional or subregional sharing of fire suppression resources is a form of risk-pooling. Because the risk of large-scale fires occurring simultaneously in all countries in a regional or subregional grouping is slight, resources on standby in a member country not threatened by fire can be used to augment those in the country or countries where fire suppression resources are fully employed. This form of risk-pooling forms the basis of, and economic justification for, the two SRFAs.[34]

Because the overall risk of transboundary haze and the fires that cause it is so unevenly spread across the various areas of the region, the subregional level is the key in organizing and carrying out cooperative mitigation-related activities under the ORHAP. The same is true of monitoring that directly supports fire management, such as detecting large-scale fires, and tracking or predicting their future movements. The subregional level is, therefore, an important focus of activities under all three of the RHAP's components, not just "firefighting," as the designation "Subregional Firefighting Arrangement" may imply.

Additional Factors and Issues

Risk-pooling among AMCs via sharing of fire suppression resources during periods of peak demand makes eminent sense also from the point of view of efficiency.

Operationally, there are many ways in which risk-pooling might be implemented. Not all of these are practical. For example, the concept of all AMCs sharing fire suppression resources would appear to have much to recommend it. An obvious advantage at the regional level would be that the wet and dry seasons in the northern and southern portions of the ASEAN grouping are reversed. This fact would appear to give rise to complementarities in the sharing of fire suppression resources among the AMCs. But from a logistical and operational point of view, this possibility is not encouraging. The practical problems involved in shipping fire suppression equipment and personnel from, say, Singapore overland via Malaysia and Thailand to the Lao People's Democratic Republic (Lao PDR) would pose daunting practical problems. Myanmar assisting the Philippines in fire suppression would be equally impractical. Thus, the SRFAs were formed as a logical and efficient response to the possibilities offered by risk-pooling and resource-sharing at the international level, as well as the limitations imposed by geography and transport.

Ultimately, considerations led to SRFAs forming the foundation for regional cooperation in fire management and suppression.

Although formulation of SRFAs took account of both the potential for resource-sharing as well as its limitations, effective cooperation at the SRFA level has posed operational issues that the ORHAP must address if SRFA member countries are to reap maximum benefits.

Means of Resource-Sharing

Ultimately, fire suppression resource-sharing must be able to be activated quickly if it is to be cost-effective. In addition to shipping arrangements for personnel and equipment being agreed in advance, immigration and customs preclearance procedures must also be in place if movement of personnel and equipment is to be carried out at short notice. But putting preclearance procedures into place presumes that a number of fundamental choices have already been made. These relate to exactly what is meant by "resource-sharing" in the SRFA context, since this is a concept that can be operationalized in a number of ways.

The ORHAP rules out the possibility of each SRFA maintaining a physical inventory of fire suppression equipment warehoused within one of its member countries, since this would require a large number of difficult issues to be resolved. Examples include the following. What types of equipment are to be kept in the inventory? Is it permissible for the equipment to be used by individual member countries at their own discretion, or must the decision for use be made jointly? How will duplication of equipment and effort be avoided? More important, who is to finance the initial purchase of equipment, its warehousing, and maintenance costs, and its upgrading as and when required?

Perhaps a more important question than any of the above is that of which equipment should be held in a joint inventory. The answer to this question ultimately depends on how the SRFA's fire suppression capability has been programmed to complement a member country's national-level suppression capabilities. This in turn depends on national-level FSMPs already in place, and the provisions they contain for using complementary suppression resources sourced from the SRFA level. A major obstacle to ASEAN resolving its transboundary haze pollution problem is the fact that not all haze-source AMCs have FSMPs in place. Because of this, a joint-inventory approach to fire suppression resource-sharing at the SRFA level does not appear to be feasible.

Operationally, this reflects a fire management capacity that falls short of the required level. Immediate action at the subregional level is therefore critical to ensure that the risk of economic, social, and environmental damage resulting from further transboundary haze is reduced to the absolute minimum, given existing time, resource, and other constraints. Concerted measures for immediately upgrading fire management capacity in the region's most haze-prone geographic areas must be undertaken at the subregional level emphasizing cost-effectiveness.

Resource-Sharing Agreements

In the context of the ORHAP, "resource-sharing" means that an agreement would have been reached among SRFA member countries that allows fire suppression personnel and equipment from one SRFA member country to be temporarily used in another, upon activation of the arrangement by the country requesting assistance in fire suppression.

However, even this system of resource sharing requires a number of issues to be addressed, most of which relate to how the personnel and equipment from the providing

The ORHAP rules out the possibility of each SRFA maintaining a physical inventory of fire suppression equipment warehoused within one of its member countries

country are to complement personnel and equipment in the recipient country. For example, how will geographic positioning of the SRFA-provided equipment and personnel be determined? Which country's chain-of-command will be used, or how will chains-of-command be harmonized or integrated? How will language differences (if any) be addressed? Will suppression teams from the two countries be merged, work in tandem, or work in parallel as independent units?

Resolving these issues essentially requires that a subregional-level FSMP incorporating resource-sharing arrangements be formulated and implemented.

The ORHAP identifies the national level as being the key in activating fire management and suppression resources from outside the region

Such a plan should also incorporate relevant resource-sharing arrangements for monitoring and prevention in addition to fire management. Implementation of these arrangements would require negotiation of international agreements

Finally, the issue of whether the national, subregional, or regional level is the appropriate point of contact when activating fire suppression resources originating from outside the ASEAN region must be clarified. The ORHAP identifies the national level as being the key in activating fire management and suppression resources from outside the region. Requests for assistance in fire suppression directed to countries outside the ASEAN region have in the past efficiently come from the national level.

There are numerous operational reasons (e.g., the need to arrange preclearance of personnel and equipment) why this approach allows deployment of external resources in the shortest possible time.

This historically-evolved arrangement of mobilizing fire suppression resources from outside the ASEAN region by national-level authorities is therefore retained under the ORHAP.

National and Subregional Level Operational Linkages

A basic issue behind the regional cooperation to address fires and haze is the fundamental conflict between natural resource management (land conversion) policy at the national level, and the obligations of the countries to ensure that haze pollution originating within their territorial boundaries does not violate the airspace of other countries. It is a basic assumption of the ORHAP that this conflict will remain in the foreseeable future.

Before describing the legal framework for the subregional FSMP, it is necessary to clarify the linkage between the national and subregional levels, since these have important implications on national sovereignty within ASEAN.

ORHAP activities to be carried out at the subregional level must avoid violating an individual member country's national sovereignty in two key areas.

First, the physical entry of fire management personnel and equipment from one member country into another's territorial boundaries may be triggered only by the requesting country. The host country alone must decide when the threshold at which large-scale fires can no longer be contained by national fire management resources has been breached, and suppression resources drawn from the supranational level will be required to prevent haze from violating another country's airspace.

Second, the deployment of resources drawn from the supranational level must take place on the basis of an agreed subregional FSMP, rather than on an ad hoc basis. The subregional FSMP should, as a first step, sort out efficient deployment of national fire management resources.

Only then should deployment of supranational resources be integrated into the national-level framework.

This would appear to leave some issues unresolved. First, the matter of requiring that a national mobilization plan include provisions for fire suppression resource contributions from the supranational level could seem to contravene national sovereignty. Second, and more important if no mobilization plan yet exists (or ever will) at the national level, this would negate the possibility of organized supranational resource-sharing at the subregional level. These points underscore the need for a clear legal framework.

Legal Framework for SRFA-Level FSMP

These problems become irrelevant unless and until the national sovereignty issues relating to SRFAs are sorted out. SRFAs (or any other supranational ASEAN bodies) do not have a mandate to sort out the national FSMPs of individual AMCs, or even to require that such plans be prepared. But SRFAs *do* have a mandate to provide organized arrangements for supranational fire suppression resource-sharing.

Several aspects of the rationale for establishing SRFAs are relevant. They are a form of risk-pooling; the least-cost way of collective action in preventing haze pollution from crossing international boundaries; and they are cost effective. Taking these considerations into account, the most efficient framework for organizing fire suppression resource-sharing arrangements is through SRFA-level FSMPs prepared only for those areas, within the relevant SRFA's geographical jurisdiction, with the highest level of perceived risk of generating transboundary haze.

Thus, the FSMP into which fire suppression resources drawn from the supranational level are to be integrated is not an overall national FSMP. Instead, it is a geographically-specified FSMP that intensively focuses suppression resources into those areas of an SRFA's jurisdiction that carry an extreme level of risk. As long as the relevant authorities in those specified areas agree to participate in the formulation and implementation of the plan, national sovereignty is in no way compromised.

Sharing of resources drawn from the supranational level will be significant during the FSMP's formulation phase. Both the panel of national fire management experts and the donors should remain closely involved in the formulation of the plan, which is a process that must ultimately be endorsed by HTTF and AMMH. The formulation stage of the SRFA-level FSMP should sort out the issues relating to its personnel, training, equipment, and communications requirements. The recurrent costs of maintaining the level of readiness designed to be achieved will also be derived from the plan as the formulation process proceeds.

The fire management personnel of the transboundary-haze-source-countries must take due responsibility for the FSMP, since it is their country that must implement and execute the plan. Donors also have an important role to play through technical and financial support.

In all matters relating to the functioning of SRFAs, HTTF's, and AMMH's, close supervision is essential in solving issues and providing guidance.

Since the most haze-prone areas of the ASEAN region lie within the jurisdiction of SRFA-Sumatra, its FSMP will be formulated first. From this plan, all relevant training, equipment, communications, and other requirements for implementing the plan will be derived, and cost estimates and financing plans worked out.

Once the FSMP for SRFA-Sumatra has been formulated, complementary monitoring and prevention can be identified and integrated into the plan. This will be accomplished by adding (and properly integrating) all relevant

SRFAs have a mandate to provide organized arrangements for supranational fire suppression resource-sharing monitoring and prevention to be carried out at the SRFA level, into the FSMP.

If the FSMP of SRFA-Sumatra were successful in reducing the risk of transboundary haze within its member countries, it would serve an important wider purpose of providing a model for other subregional FSMPs.

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Time Frame to Implement the Operating Procedure

The Operating Procedure for activating firefighting resources spans all actions relating to formulation, linkages, and implementation of the FSMPs. As conceived in the ORHAP, formulation and implementation of FSMPs in eight provinces of Indonesia, linking of these eight FSMPs at a national level, and its formulation and implementation for SRFA-Sumatra and SRFA-Borneo would complete the Operating Procedure as currently envisaged.

The time frame for full-scale implementation of the operating procedure depends chiefly on two variables.[35] The first and most important of these is the amount of time required for formulating and implementing FSMPs in the most haze-prone geographic areas of the ASEAN region. The other is the time needed for putting into place legal agreements for resource-sharing arrangements at the subregional level.

The geographic areas requiring the greatest degree of upgrading of fire management capacity comprise eight provinces of Indonesia. The first four of these include Jambi, Lampung, Riau, and South Sumatra provinces on Sumatra. The other four are Central, East, South, and West Kalimantan provinces, which together comprise the Indonesian portion of Borneo.

Fire management capacity upgrading programs based on existing FSMPs are taking place and progressing rapidly in the haze-prone areas of Brunei Darussalam and Malaysia (chiefly, Sabah and Sarawak states). Emphasis must therefore be placed on using regional resources to the fullest extent to promote FSMPs in the eight Indonesian provinces.

On the legal framework for activating SRFA-level fire suppression resource sharing arrangements at the subregional level, it has been proposed that these interagency agreements be negotiated and finalized over two years, as part of the negotiation of an umbrella ASEAN Agreement or Protocol on Transboundary Haze Pollution.

Considering the nature of the process involved, it is apparent that pursuing the simultaneous formulation and implementation of FSMPs in eight provinces of Indonesia would not be pragmatic. Emphasis must instead be placed on getting FSMPs up and running in a restricted number of locales, and on making the process of formulating and implementing such plans a sustainable and replicable process. ADB's RETA 5778 has been able to catalyze agreement with donors for support.

It has been estimated that upgrading of fire management and linking of FSMPs at the community, subdistrict, district, provincial, national, and subregional levels would take six calendar years beginning in April 1999. This time frame and program for implementing the Operating Procedure for activating forest fire suppression resources is described on an action-by-action basis in the DIPs for SRFA-Sumatra and SRFA-Borneo.

While it may be tempting, considering the possible proximity of the next ENSO, to reduce the time frame, it should be remembered that achieving sustainable gains in fire management capacity is the primary goal of this exercise. The implementation of the six-year program ultimately depends on the assent of Indonesia. From the Indonesian Government's point of view, a limited first phase of formulation and implementation of base-level FSMPs would give it sufficient time to work out the details of its program of decentralization of fire suppression activities. In this regard, the sequencing of the six-year program appears appropriate. The actual time frame for implementation of the program is flexible. However, the high economic, social, and environmental costs of future transboundary haze will hopefully act as an impetus for it to be implemented as fast as possible.

Activities Under Threat of Fire Danger

The fire danger warning is a critical period of high alert and of great significance in fire management. This is because there is still the possibility to prevent fires breaking out through proper surveillance and by defusing ignition sources. Appropriate action during this period can also help to prevent a spot fire becoming a conflagration. However, an important preoccupation during this period should be complete readiness to attack any fire that breaks out and to reduce its impact to the lowest possible level.

The main activities during this period would be to further review and fully understand all field conditions; ensure the fitness of the crew and adequacy of crew structure, equipment, and facilities; go over possible alternative responses and fallback plans; establish the adequacy of skills and competency in fire and rescue operations (such as pump operation, use of breathing apparatus, assessing wind direction and counter firing, fire jumping, water bombing, etc.); inform and alert the local community and collaborating partners in firefighting (e.g., fire service, forest service, police force, civil defense, armed forces, departments of health, information, civil aviation, transportation, information, etc.); and prepare logistics (field strategies) for different terrains and land types (steep hills, vast plains, grass lands, peatswamps) and nature of fire (ground fire, crown fire, coal seam fire, etc.), varying from beating the fire, counter firing, digging trenches to chemical spraying, and water bombing.

Central to the action is surveillance, fire monitoring, and detection as immediately as possible, and communicating the details of location of fire spotted, nature, and type of fire at detection, wind speed, and temperature, etc., as precisely as possible to the coordinating and firefighting units. The information may come from satellite monitoring, observation towers, airlines, military patrols, or informants. In some instances it will be necessary (if possible) to crosscheck and verify the information to avoid confusion and time wastage.

The components of an effective system for suppression—readiness and actual fire suppression—would involve coordinating mechanisms, human resources, funding mechanisms, community response capability, adequacy of tools and equipment, fire training, logistical support, and cooperative arrangements. However, lack of attention to this phase was evident in many cases in Indonesia during the 1997-1998 fires. Field investigations in Riau and South Sumatra have shown that during the fires of 1997-1998 there were several lapses (ADB/ASEAN 1999).

Fire Surveillance and Warning

Vital information required for fire suppression and haze management is the location and extent of all fires. To strengthen surveillance capability, the Working Group of SRFA-Sumatra implemented a fire surveillance pilot project in Riau with support from Indonesia, Singapore, CIDA, and UNEP. The main activities were early detection of fires

> The implementation of the six-year program ultimately depends on the assent of Indonesia

To strengthen surveillance capability, the Working Group of SRFA-Sumatra implemented a fire surveillance pilot project in Riau with support from Indonesia, Singapore, CIDA, and UNEP

using aircraft, near real-time remote and ground based information, photo documentation of fire sites, communication of fire information to ground fire stations, rapid ground checking, and fire suppression.

Fire detection is also carried out through surveillance by ground patrols and local community members and by enlisting the cooperation of commercial airlines. A system of fully equipped fire observation towers is normally an effective means to detect and pinpoint the location of fire. But there are only a few functioning fire observation towers in the AMCs. Communication has been an area of weakness, particularly at the subnational (provincial and district) and local levels (Anon 1997a).

Fire danger warning is an area of obvious overlap between mitigation and monitoring programs. Since monitoring has to do more with fire danger rating and early warning, these have been discussed at length under that section.

When a Blaze Blows

The efficiency and effectiveness of the FSMP and dispatch system will be put to test during an actual fire, i.e., fire suppression. The response time should be as short as possible and this will happen if the fire location is correctly identified in maps and with reference to quick access.

'Combat' Plan and Action

The fire "combat" plan, which has been (hopefully) well rehearsed, is to be put into action instantly, once the news of a blaze arrives. The crew(s) and volunteers are assembled; mission explained, and directions given in quick briefing (e.g., regarding fire intensity, wind direction, water sources, escape routes, relief arrangements); tasks are clearly assigned; deployment prioritized in cases of multiple fires; crew transport organized; equipment and tools in position; and the coordinated action (say, involving ground and aerial attacks) starts to put out the fire—all in an efficient and coordinated manner. Aspects such as standby relief teams, medical assistance, provision of food and drinking water, evacuation arrangements, etc., should be such that the firefighting could be conducted uninterruptedly, as long as needed.

In remote and inaccessible areas, it may be necessary to airlift the crew or resort to aerial fire control. Wherever feasible, ground efforts can be supported through water bombing. In the cases of large fire events, firefighters will need to be supported by voluntary fire brigades, forest workers, armed forces, etc. Smoke control, through efforts to isolate the fire and to reduce the volume and effects of smoke, is an integral part of fire management. Mopping up or post-fire suppression (including felling of smoldering trees) is important to ensure that the fire is fully extinguished.

Reports indicate that during the 1997-1998 fires in Indonesia, several measures were taken in the forestry sector: direct suppression by local fire crews (forest rangers) in cooperation with army and police personnel; mobilization of fire crews from neighboring provinces; organizing local people and concession staff to fight fires; water bombing (also using chemical retardants) from aircrafts; and cloud seeding to induce rain. International emergency assistance, in addition to long-term development assistance, was received in the form of services of trained firefighters (e.g., from Malaysia), aircraft, and water bombing facilities (from the United States), along with firefighting supplies, hand tools, and other equipment (e.g., from Germany). Sophisticated technology (water bombing, cloud seeding) was used only on a limited scale and its success was undetermined.

In 1997, Indonesia reportedly had some 14,000 persons trained in firefighting of whom only 1,400 were regular staff of MOFEC (forest rangers), 8,500 persons were with forest concessions, 3,500 were with State-owned enterprises, and 600 were members of the public. These numbers appear highly insufficient. Some 8,000 firefighters battled the blaze in Indonesia for months in 1997 and 1998. Additionally, MOFEC operated its command posts for 24 hours a day at the central level in Jakarta and Bogor, and in each province. Through these posts, information and directions on fire situation and control were exchanged. In spite of involving a large number of agencies/institutions at the central, provincial, district, and local levels, the fires could not be fully controlled and final respite came only with the rains.

The failures of 1997-1998 offer several lessons for the future.

Coordination and Logistics

Lack of effective and meaningful coordination involving a large number of agencies/institutions at the central, provincial, district, and local levels was a serious problem during the 1997-1998 fire disaster. Similar deficiencies in coordination were also seen elsewhere. For example, aerial support for firefighting provided as part of emergency assistance could not be coordinated with ground action and it was, therefore, not effective. If there is no effective and efficient system in place to prevent, control, and combat fires at site, any amount of technological inputs elsewhere will not be of much use. A balancing of equipment, technology, and training is required for optimizing benefits.

Several recent reviews of the fire situation in Indonesia conclude that fire suppression measures undertaken were not effective for all types of fires (MOE-UNDP 1998, BAPPENAS 1999). Effective fire control at the local level depends on understanding of simple techniques; and at this level fires can be contained using locally available resources of personnel and equipment.

A good fire suppression strategy will more than compensate the cost of upkeep of preparedness, when compared to the value of the risks and losses averted.

Post-Fire Action

In the case of small fires, economic and environmental impacts are likely to be low. With large fires, such as those experienced in the region in 1982-1983, 1994, and 1997-1998, there will be multiple impacts—in-boundary and transboundary. Transboundary impacts are felt primarily in the form of haze pollution. Thus, the post-fire measures needed will be of two categories: (i) mitigation of environmental emergency, and (ii) rehabilitation of material damages.

The failures of 1997-1998 offer several lessons for the future

Mitigation of Environmental Emergency

This activity is to be started almost immediately after the onset of a large fire and may have to continue for days after the fire is extinguished.

Suffocating and Blinding Impacts

Transboundary atmospheric haze pollution can result in an environmental emergency with “suffocating and blinding” impacts on public health, shipping and transport, civil aviation, agricultural and industrial production, tourism, and on the general welfare of the people. It is necessary to establish and operate a system of alertness or warning based on the PSI and API indicating public health impacts of different levels of pollution. Simultaneously, it is necessary to specify the actions individuals and institutions

BOX 13 Fire Suppression—Minimum Requirements of Personnel and Equipment

The ITTO/CFC/IPB Project: National Guidelines (for Indonesia) on the Protection of Forests Against Fire specifies the following minimum personnel and equipment requirements for every 30,000 ha of forest.

(i) One mobile suppression team consisting of 34 people. The team includes one team leader, one person responsible for logistics, two drivers, and three fire crews of 10, each consisting of one crew boss and nine crew members. This team is supplied with:
- one 4WD pick-up truck (1 ton);
- four Handy Talkys (HT-5 watts), one each for the team leader and group leaders;
- one radio station (40 watts);
- two sets of hand tools;
- eight backpack pumps;
- one portable pump;
- 33 units of protective equipment; and
- one unit of logistic support such as tents, cooking equipment, first aid, and maps.

(ii) One mobile detection team comprising two people (one driver, one passenger). The team rides a trail motorcycle and is supplied with one pair of binoculars, one HT-5 watts, two forester's bolos, one backpack pump, situation maps, and logistical support. The equipment is used for initial attack.

(iii) One pump team. The number of team members depends on fire magnitude and field conditions. The team is equipped with one HT, and communication kits including whistles and semaphore flags.

(iv) One team of heavyweight equipment. The team is supplied with kits similar to the pump team.

Although these specifications appear to be appropriate for general conditions, the circumstances at national as well as lower levels require standards unique to local conditions. Land type, landscape, topography, vegetative cover, and demography are factors to be taken into account in determining specific equipment requirements.

(Source: ITTO/IPB/MOFEC 1999).

need to take to reduce the impact. Relevant actions to be undertaken at institutional level include dissemination of information about the pollution level; alerting medical institutions; emergency medical relief; supplying smoke masks, oxygen cylinders, and other emergency needs; restricting civil, industrial, educational, and cultural activities; and closing of airports and transport systems to avert accidents.

Health Care

There is insufficient knowledge on the public health implications of haze on growing children, elderly, and the infirm; and this would call for long-term monitoring. A post-haze assessment of losses or costs (direct and indirect), and identification and mapping of major haze sources and haze-prone areas is required to impress on the need to avert similar (human-caused) disasters in the future, at all costs. There is also a need for long-term planning in the health sector to mitigate the effects of forest and land fires, supported by infrastructure development, equipment and skills for air quality monitoring, health-effect alleviation, community awareness raising and education programs, structured data collecting systems, and rapid response mechanisms. These should be properly coordinated.

> There is insufficient knowledge on the public health implications of haze on growing children, elderly, and the infirm; and this would call for long-term monitoring

Demobilization

Demobilization procedure would be undertaken after the fire suppression has been completed, including:

(a) personnel demobilization: (i) recount of total personnel, (ii) checking of personnel health, (iii) rehabilitation support, and (iv) repatriation and return of persons to their respective agency;

(b) equipment demobilization: (i) each unit collects all equipment that has been used, cleans it, and fixes it if broken; (ii) checks the amount, type, and ownership of equipment before returning to Command Post/Policy Level Crisis Center (POSKO); (iii) POSKO officer checks all equipment, referring to the equipment inventory list; (iv) if all equipment has been collected, it will be returned to the owners according to the inventory list of borrowed equipment; (v) owners store the equipment in warehouses; and (vi) replacement of damaged equipment within a reasonable period.

In normal cases of annual or periodic fires where the extent and damage is limited, the main post-fire activity will be demobilization. Even in cases where the impact has been heavy and multi-faceted, demobilization (as far as it relates to firefighting) has to take place. The serious post-fire problems are to be addressed on a different footing and level.

Rehabilitation of Material Damages

Rehabilitation of burned forests, lands, and other properties would involve inventory and classification of fire damage; fire scar evaluation; loss or cost estimation; salvage operations (to remove recoverable/reusable materials); planning and implementing revegetation and replanting measures to nurture back damaged areas; and compensation for private loss to innocent persons. Mopping up of the burned area is to be undertaken before a post-fire inventory and classification is carried out. A plan of action for follow-up has to be decided accordingly—for example, to salvage the usable materials, carry out sanitary operations, rehabilitate the area by natural regeneration or artificial means, etc.

Salvage and sanitary operations to save usable timber and to dispose of the combustible materials to avoid future fires are an essential post-fire activity. The dead materials would also serve as a sanctuary for pests and diseases. Another important but often neglected part of the post-fire process is to assess the damage and to make a report on it, including important observations. Post-fire silvicultural operations would cover short- and long-term rehabilitation measures involving complete protection from damaging influences, cutting back of seedlings and saplings capable of sprouting, and a phased replanting program depending on the condition of the burned area.

When the area and damage involved is large (consequently requiring heavy investment), it will be necessary to address the situation based on a detailed rehabilitation plan. The area to be rehabilitated may include plantation forests, peat swamps, mixed hill forests (some having coal seam fires), and protected areas. Each of the different forest types would require different silvicultural treatments: sanitary felling, cleaning, promoting natural regeneration, enrichment planting, etc., in some cases; salvage felling, land preparation, disposal of inflammable materials, and replanting in other cases; and reinforced protection measures as required, in all cases, to ensure that another fire is avoided. Rehabilitation can be taken up as part of an overall IFFM for a defined geographic area.

Salvage and sanitary operations to save usable timber and to dispose of the combustible materials to avoid future fires are an essential post-fire activity

Salvaging of the residual stock, depending on the nature of burn, can be in the form of logs, fuel and charcoal, chips, or briquettes made out of pulverized wood. In most cases, however, it may not be economical and pulverized wood may have to be mixed with soil and allowed to disintegrate.

Post-fire rehabilitation often turns out to be a major investment activity.[36] For lack of resources, this important aspect of forest fire management is often neglected, leaving the remnants as a future source of fire.

Monitoring

ORHAP's Monitoring Program

For effective monitoring, numerous activities will have to be undertaken at the ASEAN regional, subregional, national, provincial (subnational), and local levels. The program activities included under the ORHAP do not necessarily cover the entire spectrum of monitoring, but represent those that are required at the ASEAN level to remove binding constraints and to ensure effective functioning of the monitoring system.

The activities that define the monitoring program of the ORHAP at present include the following:

(i) detecting wildfires;
(ii) predicting and tracking their movements and the movement of the resulting haze;
(iii) forecasting the degree to which wildfires are likely to generate haze, as well as the type or composition of emissions likely to be generated;
(iv) determining the likely health impacts resulting from typical or particular haze;
(v) determining the areas historically affected by forest fires and haze in the region, or those likely to be affected by particular types; and
vi) assessing the impact of past forest fires, including the extent of the area burned, the composition of flora and fauna destroyed, and the socioeconomic cost of particular forest fires at the local, national, and global levels.

Monitoring covers all aspects of planning and implementation—the causes, the context, and the consequences

Monitoring of the implementation of the ORHAP per se will be dealt with under the section, "Strengthening of Institutions."

Scope and Purpose

Monitoring requires several related actions: overseeing, observing, watching, checking, keeping track of, warning, regulating, testing, measuring, etc. Monitoring covers all aspects of planning and implementation—the causes, the context, and the consequences.

There are, thus, large variations in the scope, methods, types, purposes, and outputs of monitoring. Monitoring can be of an event, a process, or an output; it can be discreet, continuous, or incremental; it can be done directly, indirectly, or by proxy measures; and it can be done from ground (site) or air (remote). It can employ simple methods or measures (number, area, volume, profit) or sophisticated technology involving satellites, computers, and systems science, providing for multiple linkages (e.g., weather data, economic data, GIS) and facilities to import and export information.

The data needs of sophisticated monitoring systems are often tremendous, ranging from land-use changes and demographic trends to socioeconomic indicators, hydrometeorological factors, spatial and temporal distribution of relevant factors, and environmental standards.

In the case of forest fires and haze, monitoring covers:

(i) fire factors (e.g., weather, human activity, danger level);
(ii) atmospheric factors (e.g., air quality, visibility) including factors of human health and welfare (e.g., PSI/API, concentration of particulate matter); and
(iii) predictions (about drought, ENSOs).

Depending on the nature of activity (e.g., detection of land clearing or incipient fires, recording of weather data, tracking the movement of haze), monitoring, including information gathering, can be carried out from the ground or from the air.

Fire- and Haze-Related Monitors

Fire and haze and their consequences are linked to a large number of monitoring variables—covering climatic factors, economic and land-use policies, civil defense systems, technological capability, public health and welfare, and other related aspects.

Actions for prevention and mitigation of fire and haze involve prediction and detection of fires, and assessments of impacts. These require a combination of monitoring efforts of different nature and complexity, and coordination and integration of information from various monitoring sources. How the information (message) is communicated and acted upon is also a matter to be monitored for assessing the efficiency and effectiveness, as well as the need for undertaking refinement or improvement.

Types of monitoring data and measurements involved, with respect to fire and haze, are varied in nature, e.g., land-based measurements, ship-platform-borne measurements, aircraft-borne measurements, satellite and spacecraft-borne measurements, and a wide range of meteorological information.

To obtain high accuracy, the data need to be properly calibrated and validated. The analysis of data will require the availability of a GIS database that must comprise regional vegetation distribution map, fuel map, fire risk map, and land use map with information on fire agents, causes, etc. For combined fire-smoke analysis, this kind of database can then be linked to atmospheric chemical analyses.

The fire monitoring system based on remote sensing must provide spatio-temporal information on fire activities that will allow the production of datasets useful for a variety of purposes. Information on the location of fire requires geographic accuracy in order to know in which ecosystem type or in which land-use system individual fires or a sequence of fires are burning. The timing of fire monitoring within a season and within the day as well as frequency of observation (e.g., daily, weekly, etc.) and periods of observation (e.g., continuous or at intervals) are critical. The resolution of data must be determined in accordance with specific needs.

The manifold interactions between climate changes and human-caused disturbances of ecosystems often result in changes of fire regimes, particularly in the densely populated regions of the tropics. Climate change models for assessing the interactions and impacts of expected changes in temperatures, precipitation, and length of dry season can help to predict such developments.

An assessment of the potential impacts of climate change on fire regimes in the tropics based on Global Climate Models (GCMs) (Goldammer and Price 1998) recently indicated with a high degree of certainty that tropical closed-evergreen forests will become increasingly subjected to high wildfire risk because of land-use changes, increasing fire sources (use of fire as a land-clearing tool), and climate change (prolonged dry seasons, increasing occurrence of extreme droughts).

International fire managers need to be prepared for situations that in the near future may require the development of innovative technologies and the preparedness to accomplish tasks that may differ from today's situation. This implies a perpetual alertness. While warning of potential disaster implies a high level of confidence, a second level, or alert level, with lower level of confidence is useful from the standpoint of strategic or contingency planning. This alert level is intended to convey the message that the potential for disaster has increased, but that actions would still be limited to planning.

Upgrading Needs of the Monitoring System

There are at present no satellites solely dedicated to monitoring (including quantifying geographical extent and environmental impact) of forest fires and haze.

However, there are systems (satellite networks) from where relevant observations can be downloaded.

The "Guidelines on Fire Management in Tropical Forests" (ITTO 1997a), targeting developing regions of the tropics, state that:

The manifold interactions between climate changes and human-caused disturbances of ecosystems often result in changes of fire regimes, particularly in the densely populated regions of the tropics

There are several forest fire monitoring and information systems, mainly in industrialized countries, that can serve as prototypes

"Assessment, prediction and monitoring of fire risk and means of quantification of forest fires and other rural fires are prerequisites for fire management planning purposes. Statistical data sets can also be used to call attention of authorities, policymakers and the general public. In the tropics, it is difficult to gather such information by ground-based methods. Air- and space-borne sensors offer possibilities to less accessible and sparsely populated land areas with inadequate ground-based infrastructures."

The Guidelines recommended that AMCs:

(a) seek access to weather information from ground stations and space-borne systems, using this information for fire intelligence (the risk assessment);

(b) use existing remote sensing systems for fire detection and prediction to obtain real-time information on the location of fires; and

(c) join others in supporting the development of international mechanisms (early warning systems), to predict wildfires. Such a system would not predict occurrence, but rather would report the development of conditions that could result in serous fires. It would have to gather and interpret information from several sources, including satellites and land-based stations.

Prototypes

There are several forest fire monitoring and information systems, mainly in industrialized countries, that can serve as prototypes. Integrated systems, such as the Canadian Wildland Fire Information System (CWFIS), developed by the Canadian Forest Service, is a prototype system that is adaptable to other countries.

The CWFIS incorporates several functions and aspects: weather observations, weather forecasts, fire danger, fire behavior, fire activity, resource status, situation reports, decision support systems, technology transfer, and information exchange. The Canadian experience has shown that exchanging information among fire agencies is a precursor to developing mutual understanding. This, in turn, fosters agreements to exchange resources as no agency or nation can be completely self-sufficient in fire management. Prior interagency and intergovernmental agreements are the key to avoiding delays that can preclude effective exchanges of resources.

ORHAP and Functional Role of Monitoring

The monitoring program of the ORHAP covers three broad areas—monitoring for prevention, monitoring for mitigation, and ex post monitoring. There are obvious overlaps among them.

Monitoring for prevention includes: forecasting weather variations that are likely to increase the risk of fire and haze, monitoring changes in meteorological variables, and using the resulting data and information as inputs into the operation of the region's fire danger rating system (FDRS). The FDRS provides quantitative measurements of the level of risk of fire and haze to which a particular geographic area is exposed.

Monitoring for mitigation includes detecting wildfires, and predicting and tracking their movements; detecting haze pollution resulting from wildfires, and predicting and tracking its movement; forecasting the composition/type of emissions; and determining the health impacts of typical or particular haze occurrences in the region. Ex post monitoring includes: determining the areas historically affected by fire and haze in the region, and assessing the impact of previous instances. The ORHAP's monitoring program provides information that:

(i) permits fire management and suppression resources to be prepared and positioned in a way that allows them to be used as efficiently as possible in managing large-scale fires;

(ii) allows haze-affected populations additional time to take precautions against the adverse health impacts of impending haze;

(iii) allows haze-prone jurisdictions additional time to take actions that counterbalance an impending increase in the risk of large-scale fires and haze pollution;

(iv) allows potential haze-affected populations to be informed of the nature of the adverse human health impacts of haze pollution, and of the steps they can take to reduce these impacts; and

(v) helps sum up the ex post estimates of the economic costs of fires and haze that may be used as a guide for determining the appropriate level of future investment to offset such disasters.

Thus, the rationale of monitoring is that it greatly increases the efficiency of measures aimed at reducing the impacts of fires and haze. While monitoring tends to exhibit powerful economies of scale, future investment should be evaluated mainly on the basis of its capacity to reduce haze pollution.

Categorization of Component Activities

The ORHAP's regional monitoring system for responding to forest fires and haze consists of five broad categories of activities:

(a) an *early warning* system that predicts extended dry periods by forecasting long-term changes in weather variables;

(b) a *fire danger rating system* that identifies areas subject to heightened risk of fire;

(c) a *large-scale fire management assistance* component that detects outbreaks of wildfires and haze, and tracks and predicts their movements;

(d) a *haze, atmospheric pollution, and health component* that determines the intensity and composition of emissions from forest fires, and their impacts on human health; and

(e) an *ex post monitoring* component that assesses the damage caused by fires and haze.

Early Warning

Early warning is an essential component of any fire and haze monitoring program. An appropriate early warning system is required to alert authorities of the need to intensify preventive measures, and when appropriate, to deploy fire suppression resources to areas of heightened risk.

This is performed by an assessment and evaluation of the contributory factors such as temperature, humidity, wind speed and direction, vegetation dryness, fuel load and activities in the neighborhood; by generating forecasts of long-term changes in climatological variables; and monitoring short- to medium-term changes in the meteorological variables that provide data inputs into the operation of the region's FDRS.

Early warning of fire and atmospheric pollution hazards may involve locally-generated indicators, such as local fire-weather forecasts and assessment of vegetation dryness, or advanced technologies that rely on remotely sensed data, evaluation of synoptic weather

Monitoring greatly increases the efficiency of measures aimed at reducing the impacts of fires and haze information, and international communication systems (Goldammer 1997b). Forest fire models generally concentrate on determining if weather conditions offer the possibility of starting and spreading forest fires, supported by studies on properties of forest combustible matters, the influence of combustion, and investigations on the geometry of forest fire spreading.

There are two levels of early warning: long-term early warning mainly linked to climate factors; and medium- to short-term early warning, which considers other fire precursors for fire danger rating.

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The Climate Factor

Despite their coarse spatial and temporal resolution, global climate models (GCMs) provide the best means currently available to predict future climate and fire danger (and hence early warning) on a broad scale. Regional climate models (RCMs), with much higher resolution, are under development and will permit more accurate regional-scale climate projections.

The Canadian Fire Weather Index

The Canadian Fire Weather Index (FWI) is an example that serves as a means of early warning. Noon measurements of temperature, relative humidity, windspeed, and precipitation for different weather stations are used to calculate the component codes of the FWI. Daily FWI values are converted to Daily Severity Rating (DSR) values using a technique developed in 1959 and modified by Van Wagner (1987). This severity rating technique permits the integration of fire severity over periods of various lengths, from daily (DSR) through monthly (MSR) to seasonal (SSR) values.

The FWI System provides an assessment of relative fire potential based solely on weather observations, and does not take forest type into consideration.

The ENSO Index

The ENSO Index (ENSOI) has been found to be a useful indicator for drought (and consequently for potential fire) in Indonesia. ENSOI is a standard value of the pressure difference between Tahiti and Darwin, Australia. This index is inversely correlated with sea surface temperature (SST) anomaly. A more sensitive (warmer) SST anomaly implies a more negative ENSOI value, which in turn implies a stronger ENSO occurrence.

ENSOs are associated with global scale variations in sea surface temperature and pressure. Since there is good degree of persistence and predictability in some of the parameters, this offers possibilities for statistical forecasting, at least three months in advance.

An extensive array of buoys, collectively known as the Tropical Atmospheric Ocean (TAO) array,[37] provides continuous monitoring of SST in the Pacific Ocean. The data from this array, combined with observations from various other systems in the Global Climate Observing System (GCOS),[38] is analyzed by renowned climate centers, such as the NOAA Climate Prediction Center. The analyzed data are used for input to climate prediction models that will predict global weather patterns three to six months ahead. Institutions such as the International Research Institute (IRI), United Kingdom Meteorological Office (UKMO), and European Center for Medium-Range Weather Forecasting (ECMWF) undertake climate prediction. Most of the climate centers make their forecast products available on the Internet (Goldammer 1997d).

Country-Level Capability

Most national meteorological services (NMS) have developed a certain level of capability in long-range climate forecasting for them to predict ENSOs well in advance of their onset.

They can therefore assist their respective national authorities directly in taking appropriate fire management and drought prevention measures well in advance. Further, climate products by well-respected meteorological centers are available on the Internet that would provide further guidance and support to NMS.

Developments in Forecasting Meteorological Trends

Until recently, long-term forecasts could only provide meteorological trends one to six months in advance. However, modern long-term seasonal and interannual climate prediction models are now available that can predict weather changes such as ENSOs up to one year in advance with relative accuracy.

In addition to the long-term climate prediction models available, traditional meteorological statistics can be used to predict climatological changes.

ASEAN's early warning system should include capabilities for both long-term climate prediction modeling and long-range climatological forecasts using traditional meteorological statistics.

In addition to generating long-term weather forecasts, the ASEAN early warning system should also have the capability to perform short- to medium-term monitoring of weather variables used as inputs into the operation of the region's FDRS.

Fire Danger Rating

The danger that a forest will burn depends on the levels of fire hazard and fire risk. Fire hazard is a measure of the amount, type, and dryness of potential fuel in the forest. Fire risk is a measure of the probability that the fuel will ignite. The level of risk is usually related to careless human action, such as deliberately burning something when the fire hazard is high. Fire risk can also be raised by natural factors, such as burning coal seams. Fire hazard can be rated with a reasonable degree of scientific accuracy, while assessing the level of risk is much more subjective because human attitudes and motivation must be taken into account.

FDRSs have been devised by fire authorities to provide early warning of conditions conducive to the onset and development of extreme wildfires. The factors that predispose a particular location to an extreme wildfire threat change over time scales that are measured in decades, years, months, days, and hours. The concept of fire danger involves tangible and intangible factors, physical processes, and hazards. By definition, "fire danger" is a general term used to express an assessment of constant and variable fire danger factors affecting the inception, spread, intensity, and difficulty to control fires and the impact they cause (Chandler et al. 1983).

The constant factors in this definition are those that do not change rapidly with time but vary with location: e.g., slope, fuel, resource values, etc. The variable factors are those that change rapidly with time and can influence extensive areas at one time. These are primarily the weather variables that affect fire behavior. All the potential factors referred to in the definition must be present. If there is absolutely no chance of ignition, then there is no fire danger. If fuels are absent or cannot burn, then there is no fire danger. If fires can start and spread but there are no values at risk as may be perceived for remote areas managed for ecological diversity, there is no fire danger for values at risk.

FDRSs produce qualitative and/or numerical indexes of fire potential that can be used as guides in a variety of fire management activities

Climate prediction models are now available that can predict weather changes such as ENSOs up to one year in advance with relative accuracy

It is impossible to communicate a complete picture of the daily fire danger with a single index

including early warning of fire threat. Different systems of widely varying complexity have been developed throughout the world, reflecting the severity of the fire climate and the needs of fire management. The simplest systems use only temperature and relative humidity to provide an index of the potential for fire starts (e.g., Chandler et al. 1983). FDRSs of intermediate complexity combine measures of drought and weather as applied to a standard fuel type to predict the speed of a fire or its difficulty of suppression (e.g., McArthur 1966, 1967; Sneeuwjagt and Peet 1985). The most complex systems have been developed in Canada and the United States (Deeming et al. 1978) that combine measures of fuel, topography, weather, and risk of ignition to provide indexes of fire occurrence or fire behavior, which can be used either separately or combined to produce a single index of fire load.

While a single fire danger index may be useful to provide early warning of wildfire activity over broad areas, it is impossible to communicate a complete picture of the daily fire danger with a single index. Therefore, it is necessary to break a fire danger rating into its major components to appreciate where early warning systems for single factors fall into the overall picture of fire danger rating. These, relating to fire precursors, fall into three broad categories of (i) changes in fuel load; (ii) changes in fuel availability or combustion; and (iii) changes in weather variables that influence fire behavior (spread and intensity).

Warning Regarding Fire Precursors

Changes in Fuel Load

In all fire danger ratings, fuel load is assumed to be constant although specific fuel characteristics may be formulated for specific vegetation types or for specific fuel models. These fuel models may overlook major shifts in total fuel loads, which may be changing over periods of decades or even centuries. Fuel changes start immediately after the cessation of cultural or agricultural burning. This change usually runs in parallel with increased suppression efficiency whereby small fires under moderate fire danger conditions are suppressed early in their life. In this situation, one may be lulled into a false sense of security because the potential for high-intensity forest fires is not manifest except in extreme weather.

Thus, the first element of early warning for a potential fire risk is a major shift in the total forest fuel complex toward denser forests, with a large build-up of surface debris and a change in vulnerability of the population by living more intimately with these fuels.

Fuel Availability

The seasonal change in fuel availability as fuels dry out during the onset of the fire danger period sets the stage for severe wildfires. Under drought conditions more of the total fuel complex is available for combustion. Deep litter beds and even organic soils may dry out and become combustible. Large fuels such as downed logs and branches may burn completely. Drought stress on living vegetation not only reduces the moisture content of the green foliage but also dried plant matter such as leaves and bark can be shed, adding to the total load of the surface fuel. In extreme droughts, moist areas such as swamps dry out and are no longer a barrier to the spread of fires as might be expected in a normal fire season. Long-term moisture deficiency in itself cannot be used to forecast critical fire situations because if the smaller fine fuels are wet or green, serious fires will not occur at any time of the year.[39] However, most devastating fires occur when severe fire weather variables are combined with extreme drought.

Fire Behavior

The fire spread component of FDRSs is designed to combine the weather elements affecting fire behavior and provide a prediction of how fires will change hourly during the day. Most indexes use 24-hour rain, and daily extremes or hourly measurements of temperature, relative humidity, and wind speed to predict the rate of spread of forest fires. In some systems, notably the US National Fire Danger Rating System and the Canadian Fire Weather Index System, indexes of fire spread are combined with a long-term measure of drought to provide an index of the total severity of the fire. This is termed a Burning Index in the United States system or a Fire Weather Index in the Canadian system.

Fire spread indexes are essentially weather processors (Andrews 1991) and the data required to provide early warning of severe fire conditions depend primarily on the ability to provide adequate space and time forecasts of the weather.

The synoptic systems that are likely to produce severe fire weather tend to be well known but the ability to predict their onset depend largely on the regularity of movement and formation of atmospheric pressure systems. In Australia, the genesis of severe fire weather synoptic systems has, at times, been recognized up to three days in advance; more often less than 24 hours warning is available before the severity of fire weather variables can be determined. Extended and long-range forecasts contain greater uncertainty, and there is less confidence in fire severity forecasts at these time scales.

Even so, these forecasts are useful in fire management in that they can be used to develop contingency plans, that is, developing options, but not to implement them until the forecasts are more certain.

As improved fire behavior models for specific fuel types are developed, there is an increasing need to separate the functions of fire danger and fire spread (Cheney 1991). A regional fire weather index based on either fire spread or suppression difficulty in a standard fuel type and uniform topography is required to provide public warnings, set fire restrictions, and establish levels of readiness for fire suppression. At a local level, fire spread models that predict the development and spread of a fire across the landscape through different topography and through a number of fuel types are required for prescribed burning, suppression planning, and tactical operations. However, these systems can be confusing on a broader scale by providing too much detail. They may be influenced by atypical variation of critical factors at the measuring site and may lose the broad-scale appreciation of regional fire danger that is required for early warning purposes.

Different Variables and Different Models

The basic variables used in virtually all FDRSs are rain, temperature, and humidity. More sophisticated fire danger rating systems also incorporate data on fuel types, land-use patterns, and other variables.

A basic FDRS is indicated in the ORHAP for the ASEAN region because of its cost-effectiveness and minimal data requirements. Moreover, nearly all large-scale fires in the region are caused by direct human intervention. A blunt measure of fire danger rating is more appropriate and cost-effective in this context than a sophisticated one.

Incorporating data on fuel types, land-use patterns, and other variables significantly increases the cost of operating FDRSs, since it expands data requirements and requires

Most indexes use 24-hour rain, and daily extremes or hourly measurements of temperature, relative humidity, and wind speed to predict the rate of spread of forest fires

frequent updating of nonmeteorological data. The increased cost of a sophisticated FDRS is difficult to justify in a context of deliberate setting of fires, since the level of activity of perpetrators closely tracks increases in dryness and temperature, which create conditions ideal for burning of biomass generated from land-clearing. In such a context, perpetrator activity is only distantly related to fuel type. As for land-use patterns, the only reliable relationship between these and perpetrator activity is that specific geographic areas have been earmarked for land conversion. Obviously, such areas face a higher risk of deliberately set fires than do areas not slated for land clearing.

Data on the three important weather variables required for operating a basic FDRS are routinely collected by ASEAN's network of ground stations

Data on the three important weather variables required for operating a basic FDRS are routinely collected by ASEAN's network of ground stations. The most cost-effective means of investing in a FDRS for the region appears to be to upgrade reporting of the data collected, and if appropriate, expand or upgrade the existing network of ground stations. This would allow an operable and reliable regionwide FDRS to be put in place in the shortest possible time. Upgrading the system to include additional variables such as fuel types and land-use patterns could be undertaken later, if this is deemed appropriate in the face of changing circumstances.

The Keetch-Byram Drought Index

There are several bookkeeping methods of monitoring the seasonal development of drought. The Keetch-Byram (1968) Drought Index (KBDI) is a number representing the net effect of evapotranspiration and precipitation in producing a cumulative measure of moisture deficiency in the deep duff and soil layers. It is a continuous index, which can be related to the changes in fuel availability mentioned above and the occurrence of severe fires. The index has proven to be a useful early warning tool and is now incorporated into the US National Fire Danger Rating System (Pyne et al. 1996) and Australian Forest Fire Danger Rating System (McArthur 1967).

ASMC currently generates short- to medium-range weather forecasts daily and compiles and updates the regional rainfall data charts weekly. It can therefore forecast the location of dry spots in the region that would potentially be subject to heightened risk of forest fires. This data and information can be used in the operation of a basic early warning system, such as the KBDI, a simplified variant of which may serve the needs of the ASEAN region, given current conditions and constraints.

Basic FDRSs based on the KBDI are already in operation in two high-risk areas of Indonesia.

IFFM has institutionalized a KBDI-type system in East Kalimantan. KBDI also forms the basis of the system used by FFPCP based in Palembang, Sumatra. ASMC has been calculating the KBDI for both Sumatra and Kalimantan using rainfall data from selected stations in Indonesia. Operation of KBDI-based systems in these pilot areas over several years demonstrates that such a system can be sustained in high-risk areas of the region (Schindler 1998b).

However, establishing and operating a KBDI-based FDRS on an ASEAN-wide basis is limited by two factors. First, the system must be adopted on a regionwide basis. This constraint can be easily addressed under the umbrella of an ASEAN-wide agreement on fires and haze, provided it is agreeable to all of the member states. To be effective, such an agreement, including any provisions relating to regional cooperation in operating the FDRS, would have to be unanimously adopted.

The second constraint is that data must be provided on a regular and timely basis by national-level government agencies. The accuracy of the regional FDRS would greatly depend on timely reporting of weather data. All AMCs are now collecting data on the three base meteorological variables required for operating a KBDI-based system. However, the absence of a satisfactory formal arrangement to ensure regular relaying of such data to ASMC has been a problem. This results in uneven reporting of data to ASMC, and wide variation in the timeliness of reports.

In the absence of data from verified observations, ASMC must "fill in" the missing data by interpolation or estimation. This problem can be overcome by putting into place formal arrangements for reporting of the relevant data to ASMC.

Rainfall Deficit

Rainfall deficit is used as a local area early warning indicator. As the maximum temperature and relative humidity in the tropical areas are almost constant, then the information content of any warning index is increased minimally by incorporating these measures. The most important and probably the only important parameter will be rainfall. An alternative simpler index with more information than KBDI would be the 30-day running mean rainfall.

It is the variation from normal or average conditions that signals when warnings need to take place.

Relative rainfall deficit would be comprehensible to the public as it takes into account the environment of the area and its behavior. It relates to the community's experience of dryness and could be observed and calculated by simply having a rain gauge and keeping records, thus opening up the prospect of grassroots participation and ownership.

Other Indexes

Other similar drought indexes used elsewhere include the drought code component of the Canadian Fire Weather Index System, Australian Mount Soil Dryness Index (Mount 1972), and Drought Index used in France (Goldammer 1997c).

Although drought indexes can be built into a broader FDRS, they are most effective as an early warning system when they are maintained separately and charted to illustrate the progressive moisture deficit for a specific location. This allows the fire manager to compare the current season with historical records of past seasons. The fire manager can also make associations between level of drought index and levels of fire that are specific to the region. This overcomes the problems caused by variation of both forest and soil type, which can mask the recognition of severe drought when a drought index is applied across broad areas.

Regular charting of bookkeeping-type systems such as KBDI or the Mount Soil Dryness Index are particularly useful in monitoring the effects of below-average rainfall during the normal wet or winter season. Moisture deficits from the previous dry season may be carried over to winter. As the next fire season develops, high levels of drought may occur early in the season when, under the normal seasonal pattern, large and intense fires rarely occur. In some parts of the world, there are indexes that indicate the changes in the global circulation patterns, which may provide warning as much as six to nine months in advance of dry conditions. One of these is the ENSOI.

Initiative on a FDRS for the Region

CIDA is reviewing the possibility of supporting establishment of a KBDI-based FDRS.[40] If adopted, the CIDA initiative could

Relative rainfall deficit would be comprehensible to the public as it takes into account the environment of the area and its behavior

If a wildfire occurs, in spite of the early warning system and the preventive measures taken by the authorities, the monitoring system should then be able to detect the fire and begin tracking changes in its status

be a welcome means of extending the existing pilot KBDI-based systems (or a simplified variant of them such as the Rainfall Debt proposed in the ADTA 2999 final report, which takes dryness[41] as the predictor) to AMCs, by stages.

SRFA-Sumatra is a likely candidate for the launching of the systems. Training of the meteorological staff in the use of a common index will be a relatively easy affair (see also Appendix 4).

Large-Scale Fire Management Assistance

If a wildfire occurs in spite of the early warning system and the preventive measures taken by the authorities, the monitoring system should then be able to detect the fire and begin tracking changes in its status. The system should first determine the precise location of the fire, so that fire management resources can be quickly deployed to the fire site. The system should then track any spread of the fires and resulting haze, in order to assist national and regional authorities in managing the fire, and activate any pre-established haze response systems.

The important technical assistance activities that comprise an appropriate fire-and-haze detection and tracking system include the following.

Intensive Surveillance

Aerial surveillance can be used to detect forest fires when they are still too small to be picked up via satellite imagery. Aerial surveillance represents a first line of defense. The major drawback is its cost compared to other means of detecting fires.

However, aerial surveillance can be cost-effective under certain circumstances, particularly when it is targeted to relatively small geographic areas facing the highest risk of fire.[42]

A pilot program of aerial surveillance was conducted with UNEP assistance in Riau province of Indonesia, under the auspices of the SRFA-Sumatra. The use of SPOT imagery to further support SRFA-Sumatra's aerial surveillance program is being explored via a RHAP initiative supported by UNEP. It is planned that the aerial surveillance program will be further supported by ground surveillance under the pilot FSMP for SRFA-Sumatra. SRFA-Borneo is, meanwhile, considering its own aerial surveillance program.

Ground surveillance, which would ideally be used to complement aerial surveillance, is of limited effectiveness in some areas of the ASEAN region, since it directly depends on the availability of road or river transport. However, ground surveillance can be highly cost-effective in areas where transport infrastructure is relatively well developed, or population densities are high.

In addition to using satellite imagery, ASEAN's monitoring system for detecting and tracking fires and haze should include information from ground stations on weather conditions (visibility, weather type, and temperature), ideally reported at three- to six-hour intervals. These reports should also be used to keep fire management authorities abreast of changes in the status of particular forest fires, and to help support confirmation from the ground of hot spot and haze information derived from satellite imagery.

An appropriate monitoring system for the region would also detect, track, and predict movements of haze generated from wildfires. The negative impacts of haze on human health can be greatly reduced if communities at risk are given even minimal advance warning of haze. For the region's monitoring system to be able to give such warnings, it must be capable of performing haze transport modeling.

Transport Models

Haze transport modeling allows meteorologists to predict the areas likely to be affected by haze, and the concentration (or in some cases, even the composition) of emissions in downwind areas of large-scale fires. In order to perform haze transport modeling, the region's monitoring system must possess two distinct types of capability. First, it needs the expertise and facilities to run the haze transport models; second, it needs high-quality data to ensure accuracy of atmospheric diffusion models (e.g., wind velocity and direction, precipitation, rate of emission of pollutants, pollutant release height, and particle size).

ASEAN's capacity to perform haze transport modeling is constrained by lack of such capabilities.

The WMO Workshop on Regional Transboundary Smoke and Haze in Southeast Asia, held in Singapore on 2-5 June 1998, recognized the need to enhance regional capabilities to provide improved predictions of daily smoke trajectories and dispersion forecasts by the use of atmospheric transport models (ATMs). This would help improve understanding of atmospheric pollution in the region. Since most ATMs have been developed in other regions, models have to be adapted to AMCs.

Several aspects such as location of fires, and source intensity characterization will have to be improved.

During the haze of 1997-1998, ASMC used ATMs to generate smoke trajectory forecasts and distributed the forecasts to the AMCs through the ASMC Intranet. At the WMO meeting, the need for AMCs to have a strong regional monitoring network for fires and haze, and an upgrading of ASMC and NMS, was stressed. It was also highlighted that there has to be improved capability for atmospheric transport modeling.

Atmospheric Pollution and Health Impact of Haze

The nature and severity of the smoke emission, the direction and velocity of its dispersion, its persistence and duration (atmospheric residence-lifetime), the height at which it resides, its impacts on the economy and society, and smoke attenuation are influenced by various factors and these form the specifics of haze monitoring.

The nature and chemistry of the smoke, its particulate conversion ratio[43] and carbon monoxide/carbon dioxide ratio[44] in haze as well as its impact on visibility are influenced by the fuel type and the interaction of haze with other atmospheric pollutants. These in turn define PSI/API.

Wind movement and velocity and other climatic factors decide the residence time of haze over the atmosphere.

But a considerable amount of research is still needed to fully understand the haze phenomenon.

The negative impacts of haze on human health are closely related to the density and chemical composition of the emissions that escape from large-scale fires. During and after the 1997 haze disaster, most AMCs carried out studies of the health impacts on their populations. Most of these studies matched air quality monitoring data with haze-related complaints of patients visiting hospitals, emergency rooms, or clinics during or shortly after the haze.

In addition to generating valuable data that assist the formulation of haze response systems, the results of these studies provided a basis for estimating the economic, financial, and social costs of exposure to haze.

While this aspect of monitoring of fires and haze may at first appear to be of secondary importance, it is ultimately the cost of these

The negative impacts of haze on human health are closely related to the density and chemical composition of the emissions that escape from large-scale fires

disasters to the region that justifies investments in fire prevention, management, and monitoring. Estimating the costs of fire and haze thus provides important information to the region's decision makers in determining appropriate levels of investment to be made to prevent or reduce the impacts of such events.

Many of the data sets generated by the national-level studies on the health impacts of haze are disaggregated by a wide range of variables (e.g., age, gender, occupational category, income, days of work lost, and days of healthy life lost). The data set generated by the bilateral program of WHO in Indonesia is particularly valuable, since it includes a large number of observations of haze-related health complaints, some of which are derived from geographic areas considerably closer to the source of emissions than those generated by studies in other AMCs. Regionwide comparison of the results of these studies would be desirable, since this would improve the region's understanding of how the health impacts of haze change when it is transported over relatively long distances. Such studies are candidate initiatives under the ORHAP's monitoring component, which would be undertaken by national- and regional-level institutions.

Estimating the costs of fire and haze thus provides important information to the region's decision makers in determining appropriate levels of investment to be made to prevent or reduce the impacts of such events

Haze Warning System

A warning system for haze relies on the ability to predict deterioration in visibility in any place for as long as weather forecasting skills will permit. The most basic forecasting tool is a box model that accepts the generated smoke into a fixed volume of air.

ASMC is the primary institution that produces regional haze prediction. The air quality monitoring capabilities of national-level environmental protection agencies also enable AMCs to implement public health haze response systems, or to inform affected communities of appropriate steps to take in reducing the negative health impacts during fires and haze. The capacity of the NMS to perform all of the above roles allows them to directly support their national governments in implementing the respective NHAPs and any pre-established haze response systems.

Air Quality and Pollution Indexes

Weather and atmospheric aspects are closely linked, and there is an obvious relationship between atmospheric changes and climatic changes.

Among the many components under the GCOS program of WMO, there is one program known as the Global Atmospheric Watch (GAW). The aim of this program is to provide data, scientific assessments, and other information on the atmospheric composition and related physical characteristics of the background atmosphere from all parts of the globe.

The measurement program includes greenhouse gases, ozone, radiation and optical depth, precipitation chemistry, chemical and physical properties of aerosols, reactive gases, radionuclides, and related meteorological parameters. There is a GAW station located at Bukit Koto Tabang, Indonesia.

In addition to the WMO-GAW station, another source of air quality data comes from local environmental agencies. Many such agencies in AMCs operate a local network of monitoring stations within their country, which measure standard pollutants. In some countries, the measurements are automated and online, which have improved the efficiency of the data collection. The data are used to calculate a pollution index, either the PSI or API.

PSI is based on a set of criteria devised by the US Environmental Protection Agency (EPA). A PSI value of 100 equals legal air quality standard (or limit) and is based on risk to human health (primary standard) or nonhuman health (animals, plants; secondary standard). Under this system, the levels of key pollutants such as sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, and respirable suspended particles (PM_{10}) are used to come up with a single index, the PSI. The PSI is a health-related index, averaged over a 24-hour period, on a scale of 0-500 (see Box 8). API is a similar health related index being used in Malaysia. The other AMCs use PSI.

Air quality data reported in standardized format using air pollution indexes assist the authorities in implementing haze response systems. Even in the absence of pre-established response systems, air quality data provide a quantitative measure of risk that is easily understood by the general population. Air quality data reporting should thus form an integral part of the large-scale fire management assistance component of ASEAN's monitoring system. In some countries, e.g., Malaysia, the index is also incorporated into the NHAP, which stipulates appropriate action for different air quality levels.

Another potentially useful tool for analyzing fire-generated smoke sources, as detected or monitored by space-borne sensors, is the rose-diagram technique (Brivio et al. 1997). In conjunction with trajectory analysis, this spatial analysis technique allows the establishment of relationships between smoke pollution and potential sources, e.g., wildfires vs. industrial pollution (IDNDR 1997).

In view of the meteorological influences on haze and their health impacts, WMO and WHO have been actively associated with the measures taken to mitigate the haze problem.

As a response to the 1997-1998 fires and haze, WMO convened a Workshop on Regional Transboundary Smoke and Haze in Southeast Asia on 2-5 June 1998, to prepare an internationally supported plan to enhance the capabilities of national weather and hydrological services in transboundary haze issues. The Workshop recommendations included the following:

- enhance regional capabilities to provide needed meteorological support in the form of improved predictions of ENSO and climate variability, and daily smoke trajectory and dispersion forecasts from ATMs;
- improve the ability to characterize fire activity and track the movement of smoke and haze by strengthening present satellite-usage capabilities;
- strengthen regional monitoring efforts to assess the effects of smoke and haze on human health, to evaluate ecosystem impacts, to help validate atmospheric transport models, and characterize emission sources;
- enhance the existing monitoring networks to measure smoke and haze-related quantities including aerosol mass ($PM_{2.5}$, PM_{10}), visibility, optical depth, and meteorological parameters. Two levels of observing stations are envisaged, a base level comprising fewer measurement parameters but with a high level of consistency across the network, and a second level with a more comprehensive measurement suite. At selected sites, targeted chemical quantities including aldehydes and other trace pollutants, aerosol composition, and ultraviolet radiation are to be measured;
- establishment of additional monitoring stations at areas not presently covered by existing networks (e.g., Kalimantan);

Air quality data reported in standardized format using air pollution indexes assist the authorities in implementing haze response systems

Once the fires have been extinguished, and haze pollution indexes have fallen to more normal levels, ex post monitoring is used to assess all the impacts of the fires and haze

- promotion of the development of the next generation of satellites. The need for dedicated fire satellites to monitor fires more precisely, and the use of space-borne radar for burned area and vegetation dryness assessment and of lidar[45] systems to measure the vertical distribution of trace gases and aerosols was underlined; and
- improve the management of smoke, haze, and other transboundary pollution through enhanced efforts directed at improved information exchange and coordination.

Transboundary issues related to haze pollution, among others, require studies on the nature and intensity of haze, nature of pollutants, and their effects; surveillance of incidences of diseases; health assessment studies and medical emergency services; dissemination of information; policies on haze mitigation; and regional cooperation and coordination of activities.

Ex Post Monitoring

Ex post monitoring documents the impacts and damages of fire and haze. Once the fires have been extinguished, and haze pollution indexes have fallen to more normal levels, ex post monitoring is used to assess all the impacts of the fires and haze

Ex post monitoring of the impacts of fire includes assessing the extent of land and forest area burned. The least-cost means of estimating this is by using vegetation indexes derived from satellite imagery.[46]

From the assessment of total area burned, rough estimates of the economic and social cost of the direct destruction resulting from the fires and haze can be made. Although the type and extent of ex post monitoring undertaken depends on the objective of the exercise, virtually all information produced is of use in managing future fires and haze. The major value of ex post monitoring is that it assists decision makers in determining appropriate levels of investment in fire management, monitoring, and prevention of the effects of fire and haze, and in rehabilitation initiatives, such as reforestation programs, that in part reverse the impacts of these occurrences.

Different Initiatives

Several ex post monitoring initiatives relating to the impacts of the 1997-1998 forest fires and haze are either underway or have been completed. The most extensive of these initiatives is a phased, three-year study organized jointly by CIFOR and ICRAF, both located in Bogor, Indonesia. Financial assistance for this study is being provided by the US, with cofinancing by the European Community and Japan.

The CIFOR/ICRAF initiative will use satellite and (possibly) aerial digital photography to determine the extent and distribution of the areas burned.

It will combine this information with socioeconomic data collected by the two organizations to address the underlying causes of the fires. The study's analysis of the causes of the fires will explore a number of areas, including forest policy, valuation of forest resources, fiscal incentives for forest conversion, and the adequacy of emergency response coordination.

A comprehensive assessment of the impact of the 1997-1998 fires in Indonesia has been completed by the ADB-financed ADTA in Indonesia. The results of this study were discussed in Chapter 2.

Because the results of the ongoing and proposed studies are expected to be widely applicable, no additional investments by AMC governments in assessments of this type are deemed necessary.

Improved Information Flow for Monitoring

A detailed treatment of information needs of fire and haze management is given later in the section on Institutions. The purpose here is only to flag the crucial importance of precise and reliable information for effective monitoring of fires and haze.

The ORHAP has assigned ASMC the lead role in long-range climatological forecasting, early warning activities, and detection and monitoring of fires and haze. As part of its responsibilities, ASMC must communicate the outputs of these functions to the NMS. Conversely, many of ASMC's activities rely on the NMS for data inputs collected at the national level. The NMS thus form an important part of the region's monitoring system network. For these reasons, efficient flow of information between ASMC and the NMS is necessary.

The ASMC intranet, which was established in early 1998, is the focal point for information exchange between ASMC and NMS. Over the past two years, ASMC has made long-range climate forecasts with the support of the NMS, and the results of these forecasts have been put on its intranet. ASMC regularly obtains long-range climatological forecasts from international climate centers, updates the NOAA satellite images and hot spot information (if any) on a daily basis, and also places this information on the intranet. In addition, ASMC provides wind forecasts and trajectory tracks of pollutants during periods when large-scale fires threaten the region.

While the ASMC intranet is capable of meeting the information requirements of even the upgraded version of the ASEAN-wide regional monitoring system proposed in the ORHAP, its use is constrained by the high cost involved. User access to the ASMC intranet is currently via ordinary dialup telephone lines, which means that users must pay international call rates in order to access the facility. When digitized, most of the satellite images are to be accessed from large computer files, in some cases requiring a full hour to download.

The above constraint is being overcome as ASMC upgrades its intranet to allow user access via an Internet link instead of dialup telephone services. Recent advances in Internet security technology will allow ASMC to lower the cost of NMS' access to its products without compromising computer security. This will greatly reduce the cost of using the ASMC intranet, and encourage expansion of its use.

Monitoring Linkages

Once the ASMC intranet is upgraded to allow use of the Internet instead of dialup access, all SRFA member countries will immediately have access to all of the outputs of the ASEAN-wide regional monitoring system, making the linkage between the regional and subregional levels complete.

The linkages of monitoring activities between the subregional and national levels are important and have been discussed in the context of the FSMP of SRFA-Sumatra. This is intended to be used as a template for other such plans at the subregional (and even the national) level, so the linkages involved would be similar.

Monitoring under the FSMP of SRFA-Sumatra

In the process of formulating the FSMP for SRFA-Sumatra, complementary monitoring activities to be carried out at the SRFA level will be identified and integrated into the plan.

To maximize the chances of the success of the FSMP of SRFA-Sumatra, several monitoring activities should be carried out. First, pollution indexes across SRFA-Sumatra member

> The ASMC intranet, which was established in early 1998, is the focal point for information exchange between ASMC and NMS

countries should be harmonized. Since all AMCs use PSI as the standard (apart from Malaysia, which uses API), standardization of the PSI and API will not only benefit the SRFA-Sumatra member countries, but the entire region.

Harmonization of pollution indexes is not the same as standardization. Standardization implies that all SRFA-Sumatra (or ASEAN) member countries adopt the same air pollution index. Standardization is, therefore, a much more stringent action than harmonization. Harmonization would merely involve creation of a table of equivalent values for PSI and the API, so that each given value on the PSI would have a corresponding equivalent value on the API. This could be accomplished at a relatively low cost.

To ensure that the FDRS estimates the risk of large-scale fires and haze in the region as accurately as possible, an international agreement may be necessary in order to provide the legal basis and mandate for sharing information in a systematic and timely manner. The absence of this remains a serious constraint to the establishment of an effective monitoring system.

Finally, the algorithms used in the satellite detection of hot spots should be harmonized, both for the ASEAN region as a whole, as well as for existing (and future) SRFAs. Since at present, the algorithms used in hot spot detection differ (e.g., the threshold temperature at which a red-color hot spot indicator appears on the monitor), their harmonization would allow the region's various satellite-based large-scale fire detection systems to be fully integrated. This would enhance hot spot detection and tracking capability at both the ASEAN and SRFA levels. The end result would be improved efficiency in the positioning of fire management resources on the ground in the region's most fire-and-haze prone areas. This in turn would reduce both the prevalence of, and the cost of, managing forest fires and haze in the ASEAN region.

An international agreement may be necessary in order to provide the legal basis and mandate for sharing information in a systematic and timely manner

Regional Monitoring Network

The centerpiece of the ORHAP's monitoring program is a network of national- and regional-level institutions that include ASMC, the AMCs' national meteorological agencies, and related agencies such as the national-level aerospace and technological agencies. Together, they receive and collect the latest information on fires and transboundary haze; where local capabilities are available, they will undertake analysis and processing of the data; and finally disseminate the outputs to concerned agencies and national authorities for appropriate action. Under the monitoring program, upgrading of the national-level agencies will occur, with emphasis being placed on communication links with ASMC, for enhancing two-way exchange of data and information.

One of the most critical areas of management of fire and haze information is data exchange and coordination. This is particularly true for institutions such as ASMC, which process information for the region. It is equally important that output products of ASMC be efficiently disseminated to the NMSs. The WMO Workshop held in Singapore, 2-5 June 1998, recommended the enhancement of the system for dissemination of data products and other relevant information, through the use of the Global Telecommunication System (GTS) for meteorological data and gridded model outputs, and the Internet or intranet systems for nonstandard products. It also recommended that there be an increased exchange of critical information on fires and haze, especially rainfall data, air quality data, trajectory and dispersion forecasts, hot spot data, and climate forecast information. It also suggested that such products be harmonized to support effective real-time decision making.

While ASMC will be the regional center for fire and haze information and forecasts, there is an option for NMSs to seek input from other Regional Specialized Meteorological Centers (RSMCs) through bilateral arrangements. In this way, NMS can further enhance information exchanges by linking up with other national, regional, and international organizations and scientific programs, sharing common interests.

Role of ASMC

ASMC plays a lead role in detecting and monitoring large-scale fires and haze in the region. Its mitigation assistance activities include detecting and locating large-scale fires and haze, and predicting and tracking their movements using satellite imagery and its existing haze transport model. Once ASMC enhances its modeling capability further by using a more advanced model, its role in large-scale fire management assistance will be considerably expanded.

In carrying out its large-scale fire management assistance activities, ASMC uses a suite of satellites for detecting and locating hot spots and smoke plumes. The two NOAA satellites currently in use orbit the earth around the north and south poles. Upgrading of ASMC's system to allow it to combine GIS techniques with its current hot spot detection capability is under consideration. Relaying the exact coordinates of detected fires to fire management command posts on the ground would allow them to be positioned for maximum efficiency.

In addition to the NOAA satellites, ASMC also uses GMS, which produces an image of the same location every hour. This is useful to track the spread of haze in the region. ASMC and other agencies are at present exploring possibilities for using the Defense Meteorological Satellite Program (DMSP) satellite, which can image nighttime fires in visible light.

Satellite imagery is the primary tool that ASMC uses to detect and locate fires, but this is only a part of the mitigation program. The other aspect is locating, tracking, and predicting the movements of haze resulting from large-scale fires.

To perform this task, ASMC must be capable of performing atmospheric transport modeling. This capability would also allow it to monitor the concentration of the particulate matter that makes up haze pollution, which is what ultimately has an impact on human health. But upgrading of ASMC's capability in haze transport modeling and monitoring will only produce maximum benefits if complementary capabilities at the national level are also upgraded.

Strengthening of ASMC

Successful implementation of the ORHAP's monitoring component requires a strong regional network of national-level hydrometeorological institutions. Prior to commencement of ADB's RETA Project, a significant amount of progress had already been achieved by ASEAN in formulating and establishing this network. ASMC had already been designated as the institution to serve as the hub of this network and as the regional monitoring center for land and forest fires and transboundary haze. It has computing resources and systems available to perform a range of monitoring activities, from detecting land and forest fires using satellite imagery to forecasting the spread and development of the transboundary haze in the region using ATMs. To enable ASMC to disseminate these processed products to the AMCs, it has set up an intranet

While ASMC will be the regional center for fire and haze information and forecasts, there is an option for NMS to seek input from other Regional Specialized Meteorological Centers through bilateral arrangements

In order to upgrade ASMC's capability, a significant amount of donor support has been catalyzed, particularly in three key areas: long-range climatological forecasting, monitoring of transboundary haze pollution, and haze transport modeling

system. The project activities, therefore, included a program for further strengthening ASMC.

In order to upgrade ASMC's capability, a significant amount of donor support has been catalyzed, particularly in three key areas: long-range climatological forecasting, monitoring of transboundary haze pollution, and haze transport modeling.[47] PARTS has been an effective vehicle for upgrading the links of ASMC with national level hydrometeorological institutions.

ASMC's access to the supercomputer at the Meteorological Service of Singapore would theoretically allow it to run any computer-based meteorological model in existence. However, the center has yet to use such models. This capability will be improved via one of the subprojects under the US-funded SEA-EI. Under this subproject (Climate Impact Forecasting—Climate Information System for Southeast Asia), a state-of-the-art regional climate change model will be installed at ASMC. On-the-job training at ASMC, secondments, and exchange visits of ASMC staff to the facilities of NOAA, which is the agency implementing the subproject, have been proposed.

ASMC already has the capability to forecast long-term weather variations (e.g., ENSO) from analysis of statistics. No upgrading of the statistical forecasting capability is therefore required for the region to produce long-range forecasts of this type.

For its own part, ASMC will extend its training program for staff from national meteorological institutions of AMCs.

Strengthening of NMSs

The NMS have varying capacities to carry out collection, processing, and dissemination of information on fires and transboundary haze. Basically, each NMS is responsible for collecting fire and haze data in its own country. This is usually performed through institutions established by WMO, which sets guidelines and basic requirements of systems needed to exchange data between its member countries. At the national level, each member country establishes its own weather-observing network to fulfil its needs. As a result, the more advanced NMS in the region, such as that in Thailand, have an efficient system to collect meteorological data inclusive of ground and satellite data. The countries with lesser developed NMS, e.g., the Lao PDR, have a limited capacity to collect meteorological data from its network of land stations and no means of reception of satellite data. There is a need to strengthen the capacities of the NMS to provide timely warnings and forecasts needed to anticipate fires and haze, and thus to assist decisions made to carry out appropriate action plans.

As remote sensing to detect land and forest fires provides an invaluable source of fire information, NMS have called for the setting up of backup facilities in the event of failure of their systems.

In addition to remote sensing information on fire and haze, it is also necessary to collect relevant information from the ground. Ground measurements provide an indication of the exposure of the population to haze pollution, affecting their health. The ground measurements also serve as a basis for the issuance of low visibility warnings for land transport, sea navigation, and air travel. Other reasons include the usage of such data for validating ATMs as well as verifying of remotely sensed parameters.

The information gathering capacity supports the NMS' initiatives to forecast smoke and haze. There are three types of forecasts: long-, medium-, and short-term. Long-term forecasts are associated with improved predictions of ENSO and climate variability. Medium-term forecasts refer to monthly or quarterly forecasts. Short-term forecasting is linked to daily smoke trajectory and dispersion forecasts from ATMs and the corresponding Numerical Weather Prediction (NWP) models that provide the input data for the ATMs. While there is no capacity in the region to run climate models, regional NMS see the potential for developing customized local medium- and long-term climate products to predict effects of ENSOs on their country. One suggestion is to establish climate centers within AMCs to produce more frequent updates of the climate forecasts and disseminate them through the Internet.

NMS have expressed interest in running ATMs to produce their own short-term forecasts of smoke and haze trajectories and dispersion. However, the accuracy of such forecasts is linked with the accuracy of the NWP input winds that drives the ATM. To improve the performance of the ATM, it is desirable to use NWP input winds from a high-resolution Local Area Model (LAM). Currently, ASMC produces trajectory and dispersion forecasts using winds from a LAM that it runs daily at the center.

The importance of ensuring national-level capability for monitoring forest fires and haze has already been underscored in several contexts. The need is to improve the capability, emphasizing a system that can cover vast areas simultaneously. The geographic and administrative division of the country is important in this regard.

Provincial Level

Provincial level monitoring capability should be aimed at decision makers. At this level, monitoring should be more accurate, and relayed faster. It will often be difficult to conduct monitoring directly at the provincial level due to vast areas involved. In national and provincial levels, use of NOAA satellite receivers supplemented by GMS and LandSat is feasible.

Local Level

Monitoring at the local level is divided into two categories, based on assignment of responsibility: local village communities and fire control groups. In the first, monitoring is emphasized as a community effort in preventing fires. To carry out monitoring at the local level, the following are required: basic data (detailed topographic map of 1:50.000 or smaller scale); an observation tower to locate fire position; ground positioning system to find and map the fire location; flags and appropriate equipment to determine speed and direction of wind at the fire location; and the necessary skills to analyze fire behavior.

Program Support

The ORHAP's monitoring program provides for strengthening capacity of National Meteorological Institutions by sponsoring and financing training programs. NMS' information management capacity needs to be expanded to provide weather forecasts as an essential part of a National Early Warning System (NEWS).

These capacities include (i) its extensive network of weather stations; (ii) its linkages with international meteorological organizations involved in global weather forecasting; (iii) its network of radiosonde (sound radio) sounding stations; and (iv) its research and climate modeling capabilities.

Because of its recent fire and haze problems, Indonesia needs to strengthen institutions such as BMG.

Further, there is need for a network of provincial fire management centers with computer facilities able to access and analyze weather and fire information derived from national and international sources. Each province should maintain a "Provincial Fire Danger Index" and regularly inform the public of fire danger conditions.

While there is no capacity in the region to run climate models, regional NMS see the potential for developing customized local medium- and long-term climate products to predict effects of ENSOs on their country

Consultative Group on Satellite Detection of Fire

This regional group consists of remote sensing experts from MACRES, LAPAN, CRISP, ASMC, UNEP, NOAA, and representatives from WMO and UN-ESCAP. They meet regularly to discuss and develop applications using new remote sensing technologies to detect land and forest fires in the region.

Two meetings of the group were held in ASMC and issues discussed included the harmonization of hot spot algorithms, a layperson's definition of hot spot, and development of a GIS for a fire danger rating index.

One of the main international assistance programs to strengthen fire and haze monitoring is PARTS

Focus of International Assistance

One of the main international assistance programs to strengthen fire and haze monitoring is PARTS, which materialized in response to a request by the Subcommittee on Meteorology and Geophysics of the ASEAN Committee on Science and Technology (see also International Assistance in Chapter 3).

Under its first component, relating to satellite usage, NOAA will help to upgrade the capabilities of ASMC and regional NMS through technology transfer and training. This will strengthen present capabilities and prepare the region for the use of the next generation of satellite products. First, it will provide software and training on the Automated Biomass Burn Algorithm (ABBA) to ASMC to do hot spot analysis using data from the NOAA AVHRR. In addition, it will provide software compatible with the new Japanese Multi-functional Telecommunication Satellite (MTS), when it is launched. NOAA will also make available data from the Defense Meteorological Satellite Program (DMSP), which has the capacity to detect fires. This will include software and training. In addition, it will develop software to measure optical depth using NOAA AVHRR data for input into the ATMs.

Under its second component—modeling of long-range transport of smoke, haze, and other pollutants—NOAA will install ATMs, in particular the HYSPLIT model, in ASMC and portable versions in selected NMS.

The aim is to help ASMC and NMS to acquire the capability to better utilize transport and trajectory models to estimate pollution dispersion, deposition, and weather. Activities include a workshop on long-range transport modeling, installation of operational models at ASMC and selected NMS, a training workshop for NMS on the use of these models, and a short course in the general area of air quality modeling and atmospheric chemistry.

Under the third component[48]—monitoring strategy for regional smoke, haze, and transboundary pollution for ensuring meaningful inputs into long-range transport models—it is necessary to select appropriate sites and identify variables for monitoring. One important variable is the optical depth. To address this, NOAA's Air Resource Laboratory (ARL) will install portable optical depth devices at selected NMS.

In addition, WMO will launch a GAW[49] aerosol program within AMCs. The regional IGBP START Secretariat in Bangkok provides a location to focus some of the activities. The basic elements of the Aerosol Project in Southeast Asia include the following.

(a) measurement of PM associated with haze and health concerns (e.g., $PM_{2.5}$ and PM_{10}), with chemical composition at a number of sites, taking advantage of existing GAW stations in the region;

(b) measurement of aerosol optical depth using shadow-band radiometers; and

(c) augmented measurements of gas phase components (e.g., sulfur dioxide, ozone, carbon monoxide, etc.) using passive samplers (with analysis carried out at existing laboratories involved in precipitation chemistry analysis) to help interpret the aerosol data, and to help characterize the chemical composition of the haze.

Yet another assistance project, outside of PARTS, is of the USAID Office of Foreign Disaster Assistance (OFDA) supporting ADPC in Thailand, to improve access to climate-related information to be used by decision makers, program designers, and implementers for improved disaster contingency planning.

Activities include the development of a climate information system that will improve climate forecasting and access by regional institutions in Asia to help them either to mitigate negative impacts or take advantage of positive impacts of climate variations. The program will also include training specific to climate variability impacts.

A project on environmental monitoring funded by USAID and implemented by the EPA includes the provision of technical assistance and training to regional governments to develop an early warning system to predict air quality problems.

It will also include the development of a pollution index as a common standard for measuring air quality in the region (PSI/API). This will help with data exchange of air quality indexes between AMCs and enhance public awareness of air pollution.

All these efforts will help to improve the regional understanding of atmospheric pollution and promote collaboration between ASMC, ASEAN NMS, and international institutions.

International Involvement in Haze and Health

Initiatives on the monitoring of haze are either taking place or planned under the ORHAP. Several international organizations are engaged in initiatives relating to health impacts of haze that will ultimately benefit the region. WHO has formulated guidelines (WHO Health Guidelines for Episodic Vegetation Fire Events) on transboundary atmospheric pollution for use worldwide, which may be applicable to the region in formulating haze response systems at the national, subregional, or regional levels.

Other donor agencies are directly analyzing the health impacts of transboundary haze that affected the ASEAN region during 1997. One of the subprojects under the US-financed SEA-EI will advance regional understanding of the chemical composition of transboundary haze produced during 1997, particularly with respect to the negative impacts of the haze on human health, and analyze the risk factors associated with adverse health impacts. This is a cooperative effort linking the national ministries of health in a number of AMCs, the Malaysia Institute of Medical Research, and the Indonesian National Institute of Health Research and Development, with the CDC (US). A particular focus is to identify respiratory and cardiac conditions warranting further investigation within the participating countries.

Under its bilateral program, GTZ is undertaking an initiative to analyze the health impacts of the 1997 fires and haze in Indonesia. This study has since been linked with the health impacts of haze project sponsored by the Impacts Center for Southeast Asia in Bogor, Indonesia.

A three-year study funded by the Australian Government and carried out by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) will analyze the composition of emissions from the

WMO will launch a GAW aerosol program within AMCs

No additional investments in monitoring of health impacts of haze are deemed to be required

transboundary haze generated during 1997, and their impacts on human health. This analysis will form one part of a broader initiative that includes other sources of emissions such as power and industrial plants, motor vehicles, and open burning. Although the study is still in its early stage, CSIRO expects that the results, which will focus on Malaysia, will also be applicable to other AMCs.

Because of the number of initiatives, as well as likely downstream financing that will result from these, no additional investments in monitoring of health impacts of haze are deemed to be required. What is required is to ensure that the results of these studies are linked with ex post monitoring initiatives that estimate the cost of recurrent fire and haze problems in the ASEAN region. In aggregate, the estimates from the ex post monitoring initiatives will provide a rough guide to an appropriate minimum level of investment in preventing or mitigating the impacts of fires and haze in the region. They will also indicate the investment required to undo the negative impacts of the fires themselves (to the extent possible) via rehabilitation programs.

Institutions

Importance and Scope

Institutions and institutional instruments are vital for ensuring efficient conduct of plans, programs, and activities at all levels. Weak institutions lead to failures and unaccomplished missions.

A recent International Forum on Forest Fire Management in Southeast Asia found that institutional weaknesses are a paramount factor causing inefficiencies in forest fire management (BAPPENAS/JICA/ITTO 1999). The situation calls for several measures to reorient and strengthen institutions and institutional instruments to ensure integrated and sustainable forest fire management, covering organizational arrangements, regulatory and legal instruments, capacity building, donor collaboration and partnerships, system or planning, and information management.

While the focus of this chapter is the institutional arrangements for the satisfactory implementation of the ORHAP, some of the related concepts are discussed to indicate the scope and need for further institutional enhancement.

Organizational Arrangements for the ORHAP

The ORHAP is an "instrument" of ASEAN to address the environmental hazards repeatedly facing the region arising from fires and haze.

ASEAN is a formal and legal regional entity, an association of 10 Southeast Asian countries, with its own institutional arrangements—policies, legal instruments, organizational structure, coordinating mechanisms, defined roles and responsibilities for members, and subregional groups. Therefore, any discussion of arrangements and assigning of responsibilities for ORHAP will revolve around ASEAN institutions and institutional instruments.

Responsibility for Forest Fires and Haze

While most countries have fire services or brigades to attend to fires in cities, wharfs, and airports, etc., forest and land fires are attended on a routine basis by a section (or subsection) of the Forest Service or National Disaster Agency. The meteorological and health departments, meanwhile, are the ones most concerned with the haze and atmospheric pollution. But the system governing this hardly exists or is extremely weak.

In regional organizations such as ASEAN, where countries are the members, it is often not possible, for practical reasons, to have elaborate sectoral units to correspond to the system of administration in member countries; and business is transacted through designated focal points, representing the institutions responsible for environmental management (including fires and haze).

Niche of the ORHAP within ASEAN

The structure of ASEAN and the system of combating fires and haze within its organizational structure are detailed below.

The ASEAN Secretariat

The ASEAN Secretariat was established in 1976 to provide secretarial services to various committees of ASEAN as well as to serve as a central administrative machinery to coordinate and carry out ASEAN programs, projects, and activities.

The Functional Coordination Bureau

The Bureau of Economic and Functional Cooperation (BEFC) is one of the four major bureaus that constitute the ASEAN Secretariat. The other bureaus include the Bureau of Trade, Industry and Services; Bureau of Investment, Finance and Surveillance; and Bureau of Program Coordination and External Relations. BEFC is headed by a Director who reports to the Secretary General through the Deputy Secretary General responsible for operations. The Director of BEFC is assisted by five Assistant Directors, one each for Agriculture, Food and Forestry; Environment; Social Development; Culture and Information; and Science and Technology. The Assistant Directors are assisted by senior officers and other support staff. BEFC covers a wide spectrum of activities coordinated by the following five committees: ASOEN, ASEAN Committee on Social Development (ACSD), ASEAN Senior Officials on Drugs (ASOD), COST, and ASEAN Committee on Culture and Information (COCI).

COST and ASMC

COST is responsible for coordinating efforts in the field of science and technology. ASMC is under the Subcommittee on Meteorology and Geophysics of COST and was established on 2 January 1993, following an endorsement of the proposal for COST by the ASEAN Standing Committee. It is colocated with the Singapore Meteorological Services (SMS). A wide range of computer and information processing facilities are available at ASMC. Facilities include the computer network of the SMS, UNIX graphics workstation, network station and mainframe computer, and supercomputer. ASMC also shares a library, conference room, training room, and data archives with SMS. Since its establishment, ASEAN scientists have conducted research and development work in ASMC.

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ASOEN and HTTF

ASOEN coordinates resource conservation and environmental protection, including such aspects as environmental management; nature conservation and terrestrial ecosystems; industry and environment; urban environment; marine environment; environmental economics; transboundary pollution; environmental education; training; and information. Established in 1989, ASOEN had six working groups to help coordinate regional programs and projects under its purview: (i) Nature Conservation; (ii) ASEAN Seas and Marine Environment; (iii) Transboundary Pollution; (iv) Environmental Management; (v) Environmental Economics; and (vi) Environmental Information, Public Awareness, and Education. ASOEN reports to the ASEAN Environmental Ministers Meeting, and in parallel through the ASEAN Standing Committee to the ASEAN Foreign Ministers.

In September 1998, ASOEN was reorganized around three Working Groups and one Task Force:

- Working Group on Nature Conservation (chaired by the Philippines);
- Working Group on Marine and Coastal Environment (chaired by Thailand);
- Working Group on Multilateral Environment Agreements (chaired by Malaysia); and
- HTTF (chaired by Indonesia).

The information services and products generated by ASOEN consist of its periodic reports on its regular and informal meetings, and the reports of its Working Groups and Task Forces, including those of SRFAs.

Putting the ORHAP into operation and formulating a system for monitoring progress has been left to HTTF, which has been given a wide latitude in interpreting the ORHAP document, and in shaping the region's infrastructure for preventing and monitoring forest fires and haze, and mitigating their impacts.

HTTF organizes its work around the three ORHAP programs: prevention, mitigation, and monitoring. Prevention activities are coordinated by HTTF-Malaysia. while HTTF-Indonesia is tasked with coordinating the mitigation activities.

Monitoring activities are coordinated by HTTF-Singapore. HTTF has established Working Groups on Subregional Firefighting Arrangements—one for Sumatra and the other for Borneo.

Putting the ORHAP into operation and formulating a system for monitoring progress has been left to HTTF

Arrangements at the National Level

Institutional arrangements for various functions relating to protection, mitigation, and monitoring of forest fires and haze vary considerably among the AMCs.

Indonesia

Three separate national-level organizations manage forest and land fires in Indonesia. BAKORNAS PB (the National Coordination Agency for Disaster Management), an intersectoral agency chaired by the Coordinating Minister for Public Welfare, coordinates fire management when fires reach a magnitude at which they are declared national disasters (such as those during 1997-1998). Inclusion of forest and land fires into the overall responsibility of BAKORNAS PB is under consideration. So far, BAKORNAS PB has addressed all types of disasters other than fires. BAKORNAS PB also has counterpart agencies at the provincial and district levels (SATKORLAK PB and SATLAK PB, respectively).

An interdepartment organization, the TKNPKHL (the National Coordinating Team for Land and Forest Fire Control Management) was established by the State Minister of Environment. The membership of the team is similar to that of BAKORNAS PB. TKNPKHL operates only at the national level, and is not mandated to operate at either the provincial or the district level. BAPEDAL (the National Environmental Impact Management Agency), which functions as the secretariat for the TKNPKHL, used BAPEDALDA (BAPEDAL's provincial-level counterpart) as its contact point during the 1997-1998 fires.

The third fire organization, PUSDALKARHUTNAS (National Center for Forest Fire Control) of MOFEC was established in 1995, following the large-scale fires of 1994. PUSDALKARHUTNAS mobilizes firefighters at the provincial, district, and field levels. At the provincial level, forest fire management is tasked to PUSDALKARHUTLA, which falls under the responsibility of the Provincial Governor. At the district level, forest fire management is tasked to SATLAK

KEHUTANAN (District Forestry Response Team for Fire Control), which falls under the responsibility of the Bupati (regent). Membership at the provincial and district levels is similar to that of the units under BAKORNAS PB.

The absence of a single line organization for fire management in Indonesia has made fire suppression ineffective and inefficient. Suggestions have been put forward that an integrated fire management system could be developed under a single line organization that is given the responsibility, authority, and adequate funding for fire suppression. As MOFEC already has a significant degree of fire management capacity, it would seem appropriate for that agency to function as the coordinating organization for agencies involved in fire suppression at all levels.

Malaysia

Responsibility for fire management in Sarawak, Malaysia, is distributed among three agencies, whose efforts are closely coordinated: the Sarawak Forest Department (forest fire protection measures, rehabilitation of fire burned areas); the Sarawak Natural Resources and Environment Board (NREB) (for implementation of regulations under the Natural Resources and Environment Ordinance); and the Fire and Rescue Department of Malaysia (fire suppression). The distribution of responsibility (to take the lead role) is based on the technical specialization of the respective agencies.

The Natural Resources and Environment Ordinance (amended up to 1 March 1998) specifies that open burning of refuse or other combustible materials and use of any land to deposit refuse without permission are offenses. The relevant provision reads: "Any person who, without the written permission of the Controller, cuts, destroys and burns vegetation in any area which is not a Native Customary Land, shall be guilty of an offence. Penalty: a fine of thirty thousand ringgit and imprisonment for three years."

The fire permit granted will specify the period and extent covered, nature of permit, and the conditions to be complied with: e.g., the phasing of burning and the area to be burned each week, period within which burning is to be completed, reduction of flame, precautions to be taken, etc.

The Fire and Rescue Department is informed of all the fire permits granted. The Board itself has no trained firefighters. During 1997, a few hundred fire permits were granted, covering an area of 2,429 ha.

NREB monitors open burnings on a daily basis to prevent their spread. It also monitors the level of atmospheric pollution. There are three API machines installed in the border areas of Sarawak. In due course, the Board will establish a fire danger warning system.

Other ASEAN Countries

The fire management structures in Brunei Darussalam, Philippines, and Singapore have direct-line organizational structures. Brunei Darussalam has a specialized fire organization, the Brunei Fire Service. Other AMCs entrust fire responsibility to a department or a ministry. The Singapore Civil Defense Force (SCDF) under the Ministry of Home Affairs is the national emergency authority providing emergency fire, rescue, and ambulance services all levels.

In the Philippines, forest fire management falls under the Environment Management Bureau (EMB) at the Department of Environment and Natural Resources (DENR). DENR staff are represented at all levels of government from the national down to the community level.

The absence of a single line organization for fire management in Indonesia has made fire suppression ineffective and inefficient

At the national level, institutional weaknesses are a paramount factor causing inefficiencies in forest fire management

Thus, in the AMCs, there are no separate fire management agencies. Since several agencies share the responsibility, coordination becomes a serious problem. As yet, there are no arrangements for single window coordination.

Proposals for Strengthening National Organizations

At the national level, institutional weaknesses are a big factor causing inefficiencies in forest fire management. The situation calls for measures to reorient and strengthen the institutions and institutional instruments for ensuring integrated and sustainable forest fire management. Measures needed include:

- policy reforms for assigning appropriate priority to forest fire management. Clear policies relating to land management and land clearance that take into account the land requirements for various purposes is an important aspect in this regard;
- revision/reformulation of laws, and their effective implementation;
- informed and organized participation of the community;
- organizational reforms for effective and efficient functioning of sustainable forest management, which would call for definition of clear functions, devolution of responsibility and authority, meaningful decentralization, and smooth and speedy flow of information;
- NHAP to be in the form of a comprehensive and integrated National Fire Plan within the overall framework of a National Forest Program;
- adequate (and additional, as required) provision of funds for fire management is an important requirement and can be achieved through innovative measures such as objective-oriented taxes/charges, and targeted funding facilities;
- establishment of a national fire management unit, with wider scope and responsibility, within the existing (or reformed) system of public forest administration and/or a single-window coordinating mechanism, capable of addressing all situations; and
- national fire management guidelines and manuals for component activities such as fire protection, prescribed burning, equipment maintenance, and firefighting operations.

National Fire Management Institutions

Institutional development has been identified as the cornerstone of any efficient fire management system.

Organizational structure and linkages of component units, and decentralization of roles and responsibilities, should be clearly defined. It should be capable of involving (and obtaining constructive cooperation of) people. While decentralization in the form of delegation of authority and decision powers to the local units is effected, it should also ensure that there is an adequate number of staff active at the decentralized level. The potential and feasibility of establishing a system of honorary fire wardens with a reserve fire protection force provided with training and periodic upgrading of skills should be investigated.

Funding for fire-management-related activities (as in the case of many other forestry activities) should be available on an adequate scale and in a timely manner. A cost-effective management is not necessarily a low budget plan. In Indonesia, forest fires and haze should be a prime candidate for the use of the reforestation fund/tax on timber extracted.

Often, a distorted incentives system can work counter to the objectives envisaged. The unnecessarily large size of forest concessions, lack of adequate control over the way the concessions are operated, lack of attention to the hardships caused to people by tenurial inequities, and conflicts are some of the details that require close attention. An additional incentive component is creation of income earning opportunities for the local community. What is needed is to ensure that people do not cause fires due to indifference and ignorance, or intentionally to register dissatisfaction or a social protest.

Coordination is an important institutional function. National and regional activities of the ORHAP will require a high degree of coordination because of the multisectoral and multilevel approach involved and to ensure effective liaison between the government, nongovernment, and international agencies and the private sector.

The inadequacies of the present coordination arrangements are well recognized. Indonesia is in the process of working out new arrangements specifying the authority and responsibility of involved institutions. The importance of this initiative cannot be overstressed. It is necessary to have a single, rationally decentralized, coordinating organization with special skills and capable of working professionally at central and provincial levels to prevent and mitigate forest fires.

From PMU to CSU

Project Management Unit

During the period when the RHAP was being put into operation through ADB assistance, a PMU was established in the ASEAN Secretariat for day-to-day administration and management of the technical assistance. The PMU was headed by the Director of BEFC, assisted by a Project Manager and an international Senior Technical Adviser, supported by an Assistant Project Manager and staff. The PMU also included four individually recruited consultants from AMCs (a forest fire management specialist, a policy and legislation specialist, a meteorologist, and an information management specialist).

Most of the field operations under the RETA Project were concluded by the end of September 1999. The responsibility for implementation of the ORHAP has also been handed over to the ASEAN Secretariat. Accordingly, the PMU was terminated and CSU took over the coordination and support functions effective 1 October 1999. The period of transition started from April 1999 with PMU and CSU working side by side, and CSU progressively taking over more functions to phase out PMU by the end of September 1999. Since CSU was installed only toward the end of the Project, the initial six-year program of the ORHAP was prepared by PMU.

Coordination and Support Unit

CSU is a unit within the ASEAN Secretariat that now fulfills the support functions for ORHAP implementation. These functions include day-to-day support to HTTF, AMMH, and SRFA meetings, preparation of relevant documents (e.g., memorandums of understanding [MOUs]), and other administrative tasks necessary for ensuring the ORHAP's smooth implementation. While many of the activities undertaken by the RETA Project operationalizing the RHAP were of a startup nature, others will have to be sustained.

The central role of CSU is to formulate an ORHAP implementation strategy over six years, using the generic guidelines laid out in the ORHAP document, and to present its results to HTTF and AMMH for consideration. All CSU activities are derived from this six-year rolling ORHAP.

CSU will further assist HTTF and AMMH in donor coordination, ensuring that programs are undertaken efficiently.

National and regional activities of the ORHAP will require a high degree of coordination because of the multisectoral and multilevel approach involved

To ensure proper sequencing and timing of donor-assisted activities, funding agencies must be made aware of upcoming changes in implementation strategy, in order to give their principal organizations time to adjust their own programs to reflect the changes.

It is the intention of ASEAN and its partners that CSU act as a clearinghouse for programs sponsored by bilateral and multilateral assistance agencies that help prevent and mitigate forest fires and transboundary haze pollution. Funding agencies are expected to put in extra resources, by providing technical advisors, to strengthen CSU.

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Regulatory and Legal Instruments

In the ORHAP context, regulatory and legal arrangements work at three levels: regional, subregional, and national. In terms of content and nature of enforcement, the regulatory and legal instruments may vary at these different levels.

The instruments may be categorized as policies and legal arrangements.

Policies Relating to Fire and Haze

There are as yet no separate policies (or legislation) relating exclusively to forest fires and haze in any of the AMCs. Some of the policy aspects relevant to the issues of fire and haze are referred to, cursorily, in other policy documents. This is true at all levels, national and supranational. There are new moves, however, as a consequence of the recent disasters caused by fires and haze, toward clear and definite policies covering all aspects of fire management.

Existing policies with special reference to fire management are those concerned with factors influencing or contributing to fire occurrence (e.g., agriculture, industry, land use, land tenure) or of those sectors affected by fires and haze (e.g., forests, environment, tourism). ADB's RETA Project reviewed national and international policies and regulations impacting on forest fires and air pollution in the ASEAN region. It identified their strengths and weaknesses, to determine where improvement is required. The desirable features of these policies, which contribute to a healthy fire regime within the all-embracing criteria of environmental conservation and economic efficiency, can be brought together as components of the fire policy. Such a fire policy should include other relevant aspects on which there is a policy vacuum (e.g., incentive system, public participation, international/regional cooperation). It is encouraging that several countries are now taking action to formulate fire policies consistent with other national policies. An important objective of the fire policies should be to establish a sustainable and functional system of fire management.

Lessons from Indonesia

A number of policy and regulatory acts in Indonesia mention fires—e.g., Basic Forestry Act No. 5/1967, Conservation of Natural Resources and Their Ecosystem Act No. 5/1990, Act No. 5/1994 on Acknowledgement of the UN Convention on Biodiversity, and Environmental Conservation Act No. 23/1997. A note provided to an ITTO Mission by MOFEC (GOI/MOFEC 1998c) listed 23 technical and procedural guidelines relating to various aspects of fire management: fire prevention and mitigation, controlled burning, Center for National Fire Control, land uses and forest fire suppression, use of forest fire suppression equipment, forest fire mitigation supplies, forest fire signposts, safety in forest fire suppression, forest fire suppression command systems, land clearing without burning, and alertness and safety.

Reports indicate that these guidelines were not adequately complied with by the parties concerned (the public, concessionaires, landowners) during the 1997-1998 fires and haze, in spite of warnings about fire risk. There is no adequate machinery to enforce the guidelines/instructions relating to zero-burning land preparation, maintenance of firebreaks, conduct of prescribed burning, and establishment of water storage dams.

Lessons on Incentives—The Philippine Case

Incentives, if rationally used, can be an effective tool of fire and haze management. An effective fire prevention incentive mechanism can ensure that a forest resource is maintained, protected, enhanced, and expanded. The Philippine example of the No-Fire Bonus Plan, employed in the Mountain Province, is instructive. Before it was enacted, the plan and its objectives were fully discussed at provincial level.

The Mountain Province, categorized as one of the 20 poorest provinces in the country, had obtained commitments from local and national leadership to focus development activities in these areas under the administration's Social Reform Agenda. Included in this program are sustainable development strategies and human ecological security. The socioecological aspects of development had to be considered as the main factor in carrying out development projects, especially in a province with rugged and mountainous terrain. Details of the plan were as follows:

General Objectives:

The following general objectives were decided upon:

- to motivate and encourage people's participation in forest conservation/ protection measures against fire outbreaks;
- to organize and strengthen community members to enable them to work toward a common goal;
- to strengthen the political will of the community and the local government units toward conservation and protection of forest resources; and
- to incorporate forest conservation and protection initiatives within the development attempts at the community level.

Specific objectives:

To attain the general objectives, specific objectives were set as follows:

- to limit or prevent, if not eradicate, forest fires in every *barangay* of the province;
- to regulate the use of fire as a tool by farmers through the issuance of a permit to burn plant residues and debris so that control measures are ensured;
- to regularly monitor and record the occurrence of fire in each *barangay;* and
- to continuously investigate the causes of fire and recommend policies to concerned agencies for implementation.

Implementation strategy:

The plan aims to provide a coordinated effort between and among local government units, other government agencies concerned, and the community toward achieving the objectives. To attain these, the political leadership in the province shall provide the following:

- coordinate development funds;
- determine from the *barangay* development plans where project funds shall be utilized;
- mobilize all *barangay* communities to participate in the plan;
- the provincial government of the Mountain Province to set up a committee to select recipient *barangays* for the No-Fire-Bonus-Plan. The committee formulates its own criteria and guidelines; and
- award projects to winning *barangays*.

Incentives, if rationally used, can be an effective tool of fire and haze management

The present policy approach to wildfires and land-use fires is often an ad hoc reaction to a situation that has already developed, rather than proactive mitigation before the emergency arises

As an absolute requirement, *barangays* that have not had any forest fires in their respective areas during the dry season, nor forest destruction through illegal logging and illegal occupation, shall be awarded development projects worth P200,000 (about $4,000). The program adopts community-based involvement in decision making relating to the identification, planning, and implementation of projects under it. The projects shall include, but are not limited to, environment-related projects such as garbage and waste disposal, water impounding projects, and erosion control measures.

Suggestions Regarding Fire and Haze Policies

Previous chapters have highlighted the urgent need for clear and comprehensive policies at the national (and correspondingly also at the regional) level, covering all aspects of prevention and mitigation of forest fires and haze. Such a policy should spell out the principles and imperatives (e.g., efficiency, social equity, people's involvement, and sustainability); development objectives and operational goals; policy measures and strategies (e.g., coordination, programming, and planning; resource mobilization and capacity building).

The present policy approach to wildfires and land-use fires is often an ad hoc reaction to a situation that has already developed, rather than proactive mitigation before the emergency arises. Policy development often does not consider the underlying causes of fire incidence and spread, which may lie outside the forest sector, such as rural poverty and deprivation, or the effects of other public policies related to land use and incentives. Sometimes, forest fires may be caused by ill-conceived forest management policies, in particular, policies of total fire exclusion that have led to fuel accumulation.

Policy objectives and measures need to be clearly articulated, and in tune with the national environmental and socioeconomic policies. Forest fire laws and regulations should be developed and translated realistically into action, linking to the overall environmental and forest laws. There should also be mechanisms with adequate capability and powers to deal with environmental crimes relating to fire. Adequate fire management involving prevention, mitigation, and monitoring should be incorporated into the criteria and indicators of SFM.

In this regard, it is imperative that the people are consulted regarding their needs and concerns about forest fire regulations. Forest rehabilitation, a post-fire activity, is also a vital aspect. Other policy concerns include rationalization of shifting cultivation, optimizing size of timber concessions, local participation, and integrated planning for fire management.

Public policy on fire should be a dynamic political manifestation of the people's concerns for their environment, health, and social welfare, and their trust in the system of resource governance. Their trust should not be betrayed, and policymakers will have to take advantage of the science and technology relating to fire management as well as lessons learned from historical experience.

At the national level, there should be a lead coordinating agency to deal with all aspects of forest fires, with a concomitant and coordinated assignment of other tasks to other appropriate government bodies. Because most fires occur within the forest estate and plantation sector, the lead agencies must have the legal authority to issue and to enforce all necessary rules and regulations for preventing and suppressing of fires. It must also have the capacity to operate effectively from the center down to the village.

In the case of Indonesia, the ITTO project, National Guidelines on the Protection of Forests Against Fire, has drafted a national policy for fire protection and management along with other ideas concerning institutional strengthening.

The proposal highlights zero-burning for land preparation, control over the forest and estate crops, and improvements in eight vital aspects: i.e., personnel, organization, facilities and infrastructure, fire prevention and suppression, funding, law enforcement, research and development, and rehabilitation of fire-affected areas.

Other recommendations tackle organizational structure of the central forest fire management organization, a fire incident monitoring and reporting system, a national network for communication, a national standard to guide the fast burning system, a national standard for forest fire equipment, a national and regional coordination guide to prevent and suppress forest fires involving related agencies and local people, and a national forest fire prevention education program (ITTO-IPB-MOFEC 1999).

Based on studies and related recommendations, Indonesia is carrying out major policy reforms. Possibilities for far-reaching changes are now being debated at all levels, nationally and locally. It is out of this debate that future policies will emerge. Some broader level aims and imperatives are already clear—regional autonomy and political democracy, decentralization and devolution of authority (greater functional and budgetary authority to the provinces in the use of natural resources), economic liberalization, increased opportunities to small- and medium-sized enterprises and local communities, participation and social audit, and focus on sustainable development.

Legal Instruments

A viable and efficient legal system is important for translating policies into action. Any failure in the implementation of rules and regulations is a major institutional weakness. Various factors combine to stall environmental laws or blunt their power.

Fire and Haze-Related National Legal Instruments

The legal (and institutional) instruments for addressing fires and haze in the AMCs need to be mutually compatible, and consistent with the common needs of ASEAN. ADB's RETA Project carried out a review of the situation in the AMCs in this regard and the outcome was generally satisfactory.

Brunei Darussalam. The legal framework for addressing forest fires is well developed. Igniting fires is a serious offence in the country. In response to the 1997-1998 fires in the ASEAN region, the mandatory fine for deliberately igniting a fire without a permit was raised from B$20,000 to B$120,000**,** a sixfold increase.

Indonesia. At the national level, policy and legal instruments relating to the use of fire for land-clearing purposes is in a state of disarray. MOFEC has issued a directive that all land will be cleared using mechanical means, and that the use of fire to clear land is therefore illegal and will not be tolerated. At the same time, there exists a directive that allows open burning, so long as a permit has been granted, but no procedure for obtaining such a permit has yet been put into place.

None of the directives, decrees, legislation, or policies at the national level have much impact at the provincial level where actual land clearing takes place.

Operationally, plantation firms are free to use open burning to clear land with impunity. In the few instances in which firms using open

At the national level, there should be a lead coordinating agency to deal with all aspects of forest fires burning to clear land have been brought to the court, none has been convicted.

Indonesia's institutional framework for addressing fires and haze is too fragmented to be effective. No fewer than 24 different government agencies are responsible for controlling land and forest fires and haze. With responsibility so widely scattered, effective control is an organizational nightmare. The existing legal instruments are without adequate capability to enforce compliance. Substantial upgrading of Indonesia's capacity to formulate and enforce legal instruments will be necessary for it to fully support the ORHAP.

Indonesia's institutional framework for addressing fires and haze is too fragmented to be effective

Malaysia. Malaysia's legal framework for controlling forest fires and haze pollution includes strict fines for open burning without a permit, although these are not always enforced in remote areas. The roads and communication infrastructure that serve the areas to be cleared are of relatively high quality, complementing Malaysia's existing enforcement capacity.

Given that Malaysia is in the process of strengthening its enforcement capacity to prevent open burning without a permit, and that the country is nearing the end of the land conversion process, both its legal and institutional framework for addressing forest fires and haze pollution are commensurate with the threat of forest fires the country faces. There appear to exist no inconsistencies between its legal and institutional framework for addressing forest fires and haze pollution.

Philippines. The legal and institutional framework of the Philippines for addressing forest fires and haze pollution is adequate, given the fact that the country has essentially completed the land conversion process. The only area in which sufficient virgin forest for land conversion remains is in Palawan, the frontier province.

The Philippines has a well-developed fire management infrastructure, the foundation of which is community-level (informal) FSMPs. Since these community-level informal plans all link with one another, the overall fire suppression effort automatically increases, as the threat of a spreading forest fire increases. Finally, at the national level, any forest fire that exceeds 25 ha in total area is declared a national disaster, allowing personnel from the military and additional financial resources to be used in suppressing such fires.

Singapore. A highly urbanized country, Singapore's natural forest is limited to only a few hectares. Most of Singapore's fire management infrastructure is geared to structural rather than wildland firefighting. With regard to its legal framework relating to fire prevention, open burning without a permit is strictly prohibited in Singapore and anyone caught contravening relevant statutes is swiftly brought to justice.

Thailand. Two decades of improving fire management infrastructure and institutional arrangements have left the country capable of managing the threat of forest fires and haze pollution. Thailand has, for the most part, completed the process of land conversion, so the country's legal and institutional framework relative to the threat of forest fires and haze pollution is adequate.

The Assessment. The RETA Project concluded that except for Indonesia, the legal and institutional frameworks for addressing forest fire and haze pollution in the AMCs reviewed are consistent with one another and with the needs of ASEAN as a whole to enable full implementation of the ORHAP.

Forest Fires and Haze-Related Supra-National Legal Instruments

International Environmental Agreements

Many environmental problems cross international political boundaries and their solution requires cooperation between countries on an unprecedented scale. In most cases, the approach to tackle problems of transboundary environment issues has been through international agreements. Through the initiatives of UNEP, more than 170 multilateral agreements pertaining to the environment have been signed.

The success of any agreement depends on how it is formulated and what it contains. The most difficult part is in its implementation. The Achilles heel of *most* of these agreements is the action to be taken if the signatory countries fail to take the necessary steps. Since many of them are "soft" instruments, there are no effective enforcement mechanisms.

Even if they cannot have powers of statutory sanction, often they exert considerable moral influence.

The ASEAN Situation

At the regional level, ASEAN's response to fires and haze has included resolutions, declarations, communiqués, and MOUs. These instruments have increasingly focused on the transboundary haze pollution issue. From the longer-term perspective of regional cooperation, these documents collectively constitute a legal framework for concerted action by member countries.

Key among these documents are the following:

- 1985: *Agreement on the Conservation of Nature and Natural Resources;*
- 1990: Kuala Lumpur Accord on Environment and Development;
- 1992: Singapore Resolution on Environment and Development; and
- 1994: Bandar Seri Begawan Resolution on Environment and Development.

The meetings that spawned these instruments also led to the endorsement of two "action plans" relating to fires and transboundary haze pollution, which included legal principles relating to ASEAN Regional Cooperation on Environmental Issues:

(i) the *Long-Term Integrated Forest Fire Management Strategy* for Indonesia, which was one of the outputs of the Bandung (Indonesia) Conference of 1992; and

(ii) the *ASEAN Cooperation Plan on Transboundary Pollution*, an ASEAN-wide plan of action adopted at the ASEAN Meeting on the Management of Transboundary Pollution held in Kuala Lumpur in June 1995.

However, since no specific operational measures were identified for these, they ultimately had little impact on fires or haze pollution; and ASEAN faced more transboundary pollution in 1997.

At the regional level, ASEAN's response to fires and haze has included resolutions, declarations, communiqués, and MOUs

ASEAN's current legal and institutional framework is weak for the following reasons:

- the regional legal framework consists solely of "soft-law" agreements that state an intent to cooperate, with no sanctions imposed against member states that fail to comply;
- other than commitments to act as "lead" countries in fire prevention, mitigation, and monitoring under the ORHAP, and a statement that all AMCs are preparing NHAPs, no definitive commitments have been made to take specific actions to address forest fires and haze either now or in the future; and
- the regional and subregional institutional arrangements for jointly responding to fire-and-haze emergencies are simply expressions of intent to allow joint responses, and as such, contain no operational details or commitments to undertake any action.

Analysis of ASEAN Legal Instruments on Fire and Haze

Supported by ASEAN/UNEP/ADB, a significant amount of background legal analysis connected with ASEAN's regional and subregional legal framework was carried out by the Indonesian Center for Environmental Law (ICEL), and it provided considerable insight about the situation.

Soft Laws and Hard Laws. Experience indicates that states are not legally committed to observe the principles and provisions of the soft laws. If states are to be legally bound to those principles, they must be incorporated into a hard law[50] such as treaties or conventions.

The experiences from the Convention illustrate the correlation between principles in a declaration as a soft law on the one hand, and conventions and protocols as a hard law on the other

The 1979 ECE Convention on Long-Range Transboundary Air Pollution is an example of an effort to make an international principle work. This Convention was the first treaty that addressed transboundary atmospheric pollution. Because it was a framework agreement that merely sets out the principles to guide future action, and because it did not formulate measures to which the parties must comply, it was not possible to implement its provisions. Therefore, the Convention did not change the status quo. The most affected parties then insisted on the formulation of emission standards. The Secretariat of the Convention later proposed, and the parties to the Convention approved, the 1985 Sulfur Protocol, 1988 NOx Protocol, and 1991 Volatile Organic Compounds Protocol.

The experiences from the Convention illustrate the correlation between principles in a declaration as a soft law on the one hand, and conventions and protocols as a hard law on the other.

Alternatives for ASEAN. ASEAN has introduced a wide range of environmental legal instruments. These notwithstanding, transboundary atmospheric pollution continues to occur. It may be argued that the Agreement on Conservation of Nature and Natural Resources is not specifically about air pollution. If that argument is true, then an agreement dealing with transboundary air pollution may be the answer to the problem. But it will certainly take a long time to have any effect.

Apart from this disadvantage, the argument for a new agreement is basically flawed. Article 19 of the Agreement on Conservation of Nature and Natural Resources specifically stipulates the state's obligation not to generate transboundary air pollution, which is accepted as an international principle. The actual problem is that the Agreement does not contain measures or standards that are useful in preventing the pollution. Accordingly, the conclusion of a protocol under the Agreement is likely to be the most possible and practicable solution to the growing transboundary atmospheric pollution in the AMCs. In addition, Article 24 of the Agreement on the Conservation of Nature and Natural Resources stipulates that in order to implement the Agreement, the state parties may adopt protocols. If this is related to Article 19, which obliges countries to prevent transboundary air pollution, then a protocol to cope is the most possible and practicable way forward.

At this moment, however, it is not possible to conclude protocols because the Agreement has no legal effect (Brunei Darussalam, Malaysia, and Singapore have not ratified it).

If for any valid reason, three countries or at least one of them still do not want to ratify it, the preparation of an independent mother agreement and its protocol becomes a must. One of the disadvantages of having to go for a new mother agreement and protocol is the negotiation process, which will be more complex with an increased number of members. Nevertheless, one of the advantages is the opportunity for AMCs to have a focused and specialized agreement concerning transboundary haze pollution in the region followed by comprehensive, detailed protocols. The other advantage is the opportunity for the AMCs to develop new and stronger provisions that were not addressed in the 1985 Agreement (Santosa et al. 1999).

Required Changes

If ASEAN is to improve its capacity to address fires and haze, several changes to the current supranational legal and institutional framework are required.

The existing "soft-law" documents can, however, serve as a basis for a strengthened regional legal framework for addressing forest fires and transboundary haze pollution. This would consist of (i) a "mother document," to provide a mandate for international agreements to be concluded for specific purposes such as addressing transboundary pollution; and (ii) a series of supporting international agreements relating to the operational aspects of addressing forest fires and transboundary haze pollution—e.g., common system of fire danger rating, sharing of meteorological information, establishment of ASEAN-wide fire monitoring network, and regional training arrangements.

The "mother document" would ideally take the form of an ASEAN Framework Agreement on Transboundary Pollution, which would be broad enough to subsume any number of subagreements on its various aspects such as transboundary haze pollution from forest fires. Agreements relating to, say, marine pollution could be just as easily included in the "mother document." The subagreements to address the various aspects of transboundary haze pollution would include:

(i) a set of detailed agreements specifying the roles, rights, and responsibilities of the various parties sharing fire suppression resources across international boundaries under SRFAs;
(ii) an agreement officially harmonizing (but not necessarily standardizing) the air pollution indexes used in AMCs;
(iii) an agreement specifying a common terminology for fire management and a common ASEAN standard specification for tools and equipment used in joint fire suppression within ASEAN;
(iv) an agreement specifying a common core curriculum for training of fire management personnel at the basic level (to promote subregional sharing of fire management personnel);
(v) an agreement endorsing universal adoption of a common FDRS and allowing universal sharing of all data necessary for operation of the system on an ASEAN-wide basis; and
(vi) an agreement on the roles and responsibilities of specialized regional centers such as ASMC.

The Current Initiative

Promoted by ADB's RETA Project, UNEP and the ASEAN Secretariat are collaborating in developing a legal framework to address transboundary air pollution, in particular haze pollution. Based on various documents prepared by UNEP and the ASEAN Secretariat, ASOEN/HTTF and AMMH at their meetings in Singapore on 25-26 August 1999 organized a feasibility study to be prepared for a single *ASEAN Agreement on Transboundary Haze Pollution*. In practical terms, this feasibility study will prepare for the negotiation of such an agreement.

The Ministerial Meeting also decided to establish a Working Group of Legal and Technical Experts (WGLTE) to serve as a

> If ASEAN is to improve its capacity to address fires and haze, several changes to the current supranational legal and institutional framework are required

negotiating forum. Another decision stipulated that the negotiation of the agreement should be completed within two years. UNEP was requested to assist in the preparation of the feasibility study and in subsequent action. After completion, the feasibility study shall be submitted to the AMMH for endorsement and negotiation of the agreement may start shortly after that.

The Ministers agreed to proceed with the negotiation for the development of an ASEAN Agreement on Transboundary Haze as soon as possible (quoted from the Joint Press Statement of the 8th ASEAN Ministerial Meeting on Environment [6-7 October 2000, Kota Kinabalu, Malaysia]). Based on the experience of environmental negotiations of similar magnitude, five sessions of WGLTE would be required to complete the negotiations. The deliberations of WGLTE shall be governed by procedural rules based on the ASEAN Protocol and Practices. Observers from selected donor agencies and regional organizations may be invited to the meetings of WGLTE. The ASEAN Secretariat will serve as the Secretariat of WGLTE. UNEP has agreed to provide WGLTE with legal assistance, including help in preparing the consecutive drafts of the agreement, and will serve as Legal Counsel. WGLTE shall report on progress of its work to HTTF and AMMH.

The ASEAN haze agreement may be complemented by a more general Framework Convention on Transboundary Air Pollution to be negotiated and adopted at a later stage

The primary objective of this initiative is to enable AMCs to develop and adopt a legally-binding agreement to combat and mitigate transboundary haze pollution. In the longer term, such an agreement may evolve into a wider legal regime addressing transboundary air pollution in the Asian and Pacific region.

The negotiation and adoption of the ASEAN Agreement on Transboundary Haze Pollution will not preclude from widening the scope of the legal framework to address transboundary air pollution beyond haze pollution. The ASEAN haze agreement may be complemented by a more general Framework Convention on Transboundary Air Pollution to be negotiated and adopted at a later stage. This convention would consolidate gains achieved by the haze agreement and could also provide a parental framework to it. Establishing a parental link would require transformation of the ASEAN haze agreement into a Protocol to the Framework Convention, which can be accomplished through technical revision of the agreement by the parties. The framework convention would allow for development of more protocols addressing other issues of transboundary air pollution. Further, it could be made open for accession by states outside the ASEAN region, widening not only the substantive but also the geographical scope. Thus, a comprehensive and coherent system of legal instruments could be created, expanding from ASEAN to the rest of the region.

Capacity Building

Capacity building promotes the improvement of efficiency. Improved capacity is reflected in effectiveness of action. As a program area, this would cover research and development involving basic and applied research; technology acquisition and transfer; establishment of a database; skills development in all aspects of fire and haze management and related education and training needs; public education and extension; improved capacity for planning, evaluation, and monitoring; updated and strengthened system of information; reorientation and strengthening of institutional instruments; infrastructure development; and coordination to ensure proactive responses. This is a broader concept and includes all factors that would add to the capacity and effectiveness of institutions.

Since some of the components of capacity building have been separately dealt with, the emphasis here will be on the two core aspects: research (science and technology development), and human resource development (education and training).

Research and Development

Research promotes technological innovation, which has a strategically important dimension.

Development of science and technology on fire and haze management includes several related aspects. Examples are tools and techniques of fire control, prescribed fires, optimal fire regimes, beneficial uses of fire, land conversion methods without the use of fire, fire behavior, monitoring systems, fire-related climate models, emission characteristics of fires, and socioeconomic and health impacts of haze. An important area is epidemiological studies on short- and long-term effects of haze on health, including effects of exposure to known and potentially harmful substances such as PM_{10}, sulfur dioxide, heavy metals, hydrocarbons, and solvent extractable compounds in haze aerosols (Abraham 1998).

With an increased number of fires (damaging hitherto safe areas such as rain forests and wetlands), and greater intensity of their impacts, it has become necessary to meet the challenge on a scientific basis. Forest fire-related research has been neglected in the past and efforts must be made to improve the situation, including provision of funds, facilities, and expertise to undertake research.

A related consideration is acquisition of technology from outside, suitably balanced to the situations in a country. A considerable amount of forest fire research has been conducted in temperate countries. It has been estimated that more than 100,000 publications (books, scientific papers, and meeting reports on fire-related subjects) exist. It should be possible to adapt some of this knowledge for tropical countries.

The tendency to concentrate on high technology inputs should be avoided, as it leads to the neglect of equally (if not more) important field actions such as fire protection measures.

Education and Training

Fire Management Training

The scope of training covers in-country training (upgrading, refresher courses), external training, and exchanging. General aspects covered in training include land and forest fire detection using satellite data, GIS, image processing techniques, hot spot algorithms, regional climate prediction, climate forecasting, methods and applications of disaster prediction, satellite monitoring, atmospheric transport modeling, atmospheric monitoring, Internet and intranet use, aerial surveillance, use of site navigation tools, and fire suppression and mitigation techniques. Training is required at all levels.

Several studies were undertaken by ADB's RETA Project resulting in suggestions to improve training methodology, course design, program delivery, and training levels for implementing the ORHAP. In this regard, three categories of training are required. (i) firefighter training, (ii) train-the-trainer training, and (iii) incident management training. A need has also been identified for training the public, including volunteers, forest communities (including loggers and concessionaires), and army and police personnel.

Situation Assessment and Improvement

Forest Firefighter Training. Forest firefighter training falls into two categories. The first is where the primary responsibility is

A comprehensive and coherent system of legal instruments could be created, expanding from ASEAN to all countries in the Asian and Pacific region carried out by forestry service-based agencies, as is the case in Indonesia, Philippines, and Thailand. The second is where it is carried out by professional firefighting and emergency services as is the case in Brunei Darussalam, Malaysia, and Singapore (although in the Malaysian state of Sabah, the forestry service also plays a significant role).

The first category requires the greatest degree of development, particularly in Indonesia. In the second category the professional fire and emergency services possess the resources to deliver training to meet their own needs. However, they are often yet to acquire and develop broad-based institutional and personnel expertise in forest firefighting.

With the exception of RFD in Thailand, the Sabah State Forestry Service in Malaysia, and a number of donor-assisted projects in Indonesia, forest firefighter training within the region is generally limited in scope.

Forest firefighter training within the region is generally limited in scope

There tends to be a paucity of trained and experienced personnel at all levels; and there is little in the way of national programs that can meet the regions' needs for future haze mitigation operations.

Thailand has developed unparalleled expertise within the region in the field of forest firefighting over the past 20 years.

It has devised systems, structures, and training programs based on best practice seen around the world, which it has adapted to wet and dry tropical environments. In addition to the basic fireline levels, the agency also conducts training in the more specialized techniques including Remote Area Fire Teams (RAFT), helicopter insertion teams (HeliTack), and aircraft fire attack.

The systems in use by RFD for forest fire mitigation, suppression, and training have been developed primarily to meet national and agency needs. They offer a good model for developing or enhancing firefighter training in other AMCs.

Directions for Regional Forest Firefighter Training. The right atmospheric and environmental conditions for another incidence of transboundary haze are likely to occur before 2002. This would require firefighting personnel from the various national agencies of the AMCs to work alongside one another. There is an urgent need for a common approach to firefighter training, at least at the most basic levels, to combat this.

The same basic forest firefighter training is conducted throughout the region, despite there being no collaboration in this regard. The general scope and content of this training is also quite similar to that carried out in countries considered to face a consistently high annual forest fire threat and which maintain large, structured firefighting organizations (e.g., Australia, Canada, and United States).

Taking into account the existing degree of commonality in forest firefighter training throughout the region, a common core curriculum can be designed and implemented by all AMCs. Such a common core curriculum should not replace the existing training programs, but should rather be used as the nucleus curriculum for enhancing existing programs.

In addition to the regular forest fire crew, training in forest firefighting should be given to voluntary fire forces, police and military, fire and rescue services, and staff of the private sector and NGOs.

For the most part, training at the level of the fireline team—the basic component in the chain of mitigation action—is more efficient when carried out locally; and this does not offer scope for centralization at the regional level.

Train the trainer and incident management training. Training of this nature is carried out through short courses, workshops, study tours, orientation programs, and fellowships.

Fire management skills occur at two levels: (a) operational level, and (b) management level. Training at the operational level imparts skills necessary for physically performing fire management and suppression. Training at the management level imparts the skills necessary for efficiently organizing operational-level activities.

Given that fire suppression techniques are similar among AMCs it would seem desirable to centralize at least some aspects of training of fire management personnel. Most economies of scale occur at the management rather than the operational level.

In the case of training for fire management trainers, the question of whether sufficient scale economies exist at the subregional level can be answered only as programs for this develop in the region.

Strengthening Existing Training Programs

ADB's RETA Project made a number of recommendations to improve fire management training programs in the ASEAN region, with particular reference to Indonesia, as follows:

- develop national competency-based training standards and implement these at all levels;
- increase the number of qualified fire instructors at all levels and locations. This would allow more local and volunteer firefighters to be trained;
- organize volunteer fire brigades and provide training to them;
- increase the number of training centers at the provincial level as a means of ensuring training under local conditions and to reduce travel costs. Establish a center for peat fire management training and research in one of the universities in Kalimantan, possibly at the University of Palangkaraya;
- determine how military personnel and equipment could be used in fire suppression efforts;
- encourage intra-ASEAN joint training curricula or programs for efficiency, cost-effectiveness, and for cross-border mobilization of personnel, especially under the auspices of SRFAs; and
- develop and implement regional training programs via exchange visits, secondments, and joint training exercises.

Applied Study on Training and Research

There are several ongoing or planned fire suppression training programs at the national, subregional, regional, and international levels aimed at improving ASEAN's capability to mitigate future large-scale fires in the region. Efforts are now underway to integrate all of these programs into a regional fire suppression training and research package. An initial step in formulating this package is the Australian Government-financed Applied Study on Formulation of a Regional Fire Suppression Training and Research Program. This study is surveying and inventorying all the fire management training programs in the ASEAN region. The overall purpose is to ensure that individual training programs avoid overlaps and that they collectively provide the ASEAN region with appropriate training in fire management at all levels. The study is also assessing ASEAN's capacity to provide fire management personnel in adequate numbers to support the ORHAP's mitigation program. Since the proposed Regional Research and Training Center for Land and Forest Fire Management at the University of Palangkaraya could function as the apex institution for any regional fire

Given that fire suppression techniques are similar among AMCs it would seem desirable to centralize at least some aspects of training of fire management personnel

The challenge now is to use the period between the last ENSO and the next to put into place an institutional framework that will prepare the region for subsequent periods of vulnerability to forest fires and haze

management training program, its suggested development path is also being closely examined by this study.

Regional Fires Research and Training Center

Following meetings of HTTF in 1998, ASEAN decided that a regional research and training facility should be established at the University of Palangkaraya in Kalimantan, Indonesia.

The idea of establishing the center itself grew out of a grassroots approach to adapting peat fire suppression technology to local conditions in Indonesia's Central Kalimantan province, under conditions of severely constrained financial and technical resources. This notwithstanding, a substantial amount of research relating to peat forests and fire management is being conducted at the university in association with recognized international institutions.

Considering that the proposed center meets the criterion of economy of scale, the ORHAP supports its establishment and will actively play a part in initiatives aimed at achieving this goal.

There was concern that the concept for a regional training facility may have been that it would conduct primary fireline training on a regional basis. This is not considered to be a viable training concept at the regional level for logistical, financial, and practical reasons. A regional training center would need to conduct training and more particularly research aimed at a higher level of fire management than simply firefighter training. Accordingly, modifications were made to enhance the scope of the center. The Hanoi Plan of Action approved by the sixth ASEAN Summit on 16 December 1998 confirmed that the "ASEAN Regional Research and Training Center for Land and Forest Fire Management" will be established by the year 2004; and AMMH requested HTTF to prepare a plan of action to implement the proposal. ADB's RETA Project supported the preparation of the implementation plan.

Donor Collaboration and Partnerships

Funding agencies have made a vital contribution to addressing the impacts of repeated forest fires and haze, providing a substantial amount of funding to short-term suppression actions. While this has no doubt been appreciated by AMCs, sustained funding of short-term fire suppression over an indefinite period is neither feasible, nor would it be an efficient use of scarce donor or affected-country resources.

The challenge now is to use the period between the last ENSO and the next to put into place an institutional framework that will prepare the region for subsequent periods of vulnerability to forest fires and haze. This preparation should be such that ASEAN will never again have to resort to crisis management as it did during the 1997-1998 fires and haze.

Accomplishing this will require donor funds to be used as efficiently as possible. While assistance projects play vital roles, it is crucial to ensure that they are fully owned by the AMCs and integrated into the ORHAP, such that the activities can run on effectively even after the external assistance is terminated. The role of donors in addressing the fire-and-haze issue will also have to be redefined. In short, their responses will have to be integrated through explicit partnerships, rather than each of the donors simply becoming aware of other donors' involvement.

A start has been made by integrating all donor activities directly into the ORHAP-DIP. When used as intended, the DIP places the onus of developing an integrated operational plan for confronting the fire-and-haze issue directly on to the AMCs and ASEAN itself. Once ASEAN has determined what actions are needed, the financial costs can be estimated, and the areas where gaps between available AMC resources and requirements exist can be identified. International organizations should determine which of these gaps each can most efficiently fill, given their particular area of expertise.

In order to underpin implementation of the ORHAP, RETA 5770 promoted partnerships between international agencies, HTTF, and AMMH. At the outset of the ORHAP, an Informal Meeting of Donors was convened to inform them of the opportunities to forge partnerships with ASEAN. At that meeting, several donor partnerships were formalized and a number of others agreed in principle.

The process of partnership formation and discussions about the tasks facing partnerships formalized earlier followed, and this process is still continuing, through informal contacts and discussions at SRFA, HTTF, and AMMH meetings, and at workshops and special discussion sessions (see Box 14 and Appendix 5).

System of Continuous Planning

Planning is an institutional responsibility, and preparation of a plan involves several institutional players, and inputs from experts and stakeholders.

The Plan Design

Conceptually, the ORHAP has all the important characteristics of a formal plan, or specifically of an action plan. But the nature and emphasis of certain levels of actions may vary when compared to a sector plan or a development plan.

However, the ORHAP can and does function within the confines of a broader planning framework.

Being operation-oriented, the ORHAP has no long-term or perspective design. The plan is divided into three operational programs with an additional component of institutional arrangements supporting these. The components and subcomponents of programs are vertically linked. Spatially, there are 12 geographic entities: nine component national plans (NFAPs), two subregional plans, and one plan covering the entire ASEAN region.

The subdivisions within a national plan will be the responsibility of the country concerned. At the lower national levels, (e.g., districts, subdistricts, villages) an FSMP is regarded as an integral part of the haze action plan. Implementation is based on a DIP of programs and program components (and each geographic unit has a DIP). The DIP contains details of activities and actions to be taken by major programs.

The consideration for inclusion of an activity in a DIP is the availability (or commitment) of funds. Such a commitment can be on the part of national governments, ASEAN, or a partner, particularly funding agencies. Accordingly, the DIP can be modified or updated continuously,

BOX 14 **Institutions Responsible for the ORHAP**

- ASEAN Ministerial Meeting on Environment
- ASEAN Ministerial Meeting on Haze
- ASEAN Senior Officials on Environment
- Haze Technical Task Force
- HTTF-Indonesia (Mitigation)
- HTTF-Malayasia (Prevention)
- HTTF-Singapore (Monitoring)
- Working Group on SRFA-Borneo
- Working Group on SRFA–Sumatra
- ASEAN Secretariat–Environment Unit
- ASEAN Secretariat–Agriculture and Forestry Unit
- ASEAN Secretariat-Information and Library Unit
- ASEAN Secretariat–Computer Unit
- ASEAN Secretariat-Culture and Information Unit
- ASEAN Specialized Meteorological Centre (ASMC)
- Dialogue Partners/Collaborative Partnerships
- NGOs/Private Sector

Once ASEAN has determined what actions are needed, the financial costs can be estimated, and the areas where gaps between available AMC resources and requirements exist can be identified

as and when resources become available or committed. The various programs and spatial components are linked by an appropriate coordination mechanism. The changes to DIP at the ASEAN regional level are monitored and endorsed by HTTF and AMMH.

Defining of Activities

The strategic formulation for action plans with objectives that can be reached only in the medium and the long term share a common architecture. The elements of this architecture and the sequence in which these are executed, are as follows. First, the problem to be addressed (or the objectives to be achieved) is stated. Second, the vehicle for fulfilling the plan's objectives is determined. Third, the parameters of the strategy (or pathway) for achieving the plan's objectives are formulated. Fourth, the outputs (intermediate goals or milestones) in achieving the plan's objectives are identified. Fifth, the tasks required for achieving the outputs are detailed. Finally, the inputs required to perform the tasks are derived from the tasks.

Even though activities in the ORHAP are scheduled for implementation in the short to medium term, the objectives to be achieved are of a medium- and long-term nature. This characterizes ORHAP as a strategic plan, to address a perceived environmental problem, i.e., forest fires and haze.

The ORHAP assumes that implementation of the plan can succeed only if all the concrete measures incorporated into it are described in exact detail, including the following variables:

(a) the exact action to be undertaken, including its major parameters,
(b) the organization taking the lead in undertaking the action,
(c) the position designation of the person ultimately responsible for ensuring that the action is undertaken,
(d) the complete financial cost of undertaking the action,
(e) the time frame during which the action is to be undertaken or completed, and
(f) the monitoring variable that is triggered when the action has been (or is being) successfully implemented.

Prioritization of Activities

Implementation of the ORHAP is to be carried out in a balanced manner, with due emphasis on the relationship of development and short-term objectives, and assigning appropriate priority to the program activities.

Normally, the priority provided to a planned action is based on its level of net contribution toward achieving the objectives with least cost and within a minimum time. For pragmatic reasons, the ORHAP assumes that the level of priority attached to a particular action is solely determined by whether or not funding for the action under consideration has been secured (this probably is a good enough proxy measure).

Thus, a country's priorities in addressing the threat of fire-and-haze disasters are to be determined solely by the level of funding it attaches to particular actions.

In the most general sense, there are, therefore, only two levels of priority that can be attached to actions relating to fires and haze: those that are funded, and those that are not.

By default, unfunded actions are deemed to have received zero priority.

The implications are that an additional variable *g* must be added to the list *a-f* given earlier, and it is the source of funding.

This variable often comprises two components: the portion of the cost of the action that is funded by the government and the portion that is funded by other sources.

Detailed Implementation Plan

The core of the ORHAP is a DIP containing the provision for actually carrying out the activities. DIPs are prepared based on commitments from ASEAN, member governments, assistance agencies, and donor countries, and also of NGOs, community groups, and other voluntary organizations.

In addition to detailing the organization responsible for each action (and the designation of the person responsible in that organization), DIPs also present a detailed matrix of the budget, source of funding, time frame for implementation of action, and a monitoring variable to determine whether or not the action has been (or is being) successfully implemented. Inclusion of the monitoring variable allows the DIP matrix to function also as a vehicle for monitoring RHAP implementation. Transparency in monitoring is assured by real-time dissemination of the entire DIP matrix to all parties concerned via a restricted-access (i.e., password-required) intranet.

While the ORHAP details the steps that ASEAN itself is to take (donor assistance only supports the steps taken by ASEAN), the full complement of concrete measures that are to comprise the implementation strategy also need to be laid out.

Since the actions are undertaken at three different levels (regional, subregional, and national), the DIP is divided correspondingly into three. The DIPs relating to the various levels together comprise the ORHAP-DIP, which collectively forms the detailed "to-do" list that guides implementation over a six-year period. The DIP developed and/or modified (by CSU), is presented to the HTTF and AMMH for approval. Once approved, it gets incorporated into the formal DIP matrix, and implementation is monitored. The actions required to support ORHAP implementation may change over time and these changes are to be reflected in the DIP.

DIPs have been prepared for each of the nine NHAPs, and for each of the two SRFAs. An umbrella DIP has also been prepared for measures to be taken at the regional level. Donor-sponsored or initiated programs, projects, or initiatives incorporated into the ORHAP are also integrated into the appropriate DIPs. For example, a donor project that promotes the ORHAP at the regional level is incorporated into the regional-level DIP, whereas a project that supports implementation of a particular NHAP[51] is integrated into the DIP for the country concerned.

Of the three levels of DIPs, the national-level DIPs tend to be the most extensive. This is understandable, since the national-level plans (NHAPs) form the foundation for all resource-sharing arrangements and actions cooperatively undertaken at the subregional or regional level, without which the entire ORHAP mechanism would be ineffective. A substantial amount of time and resources has thus been devoted to the preparation of the NHAP-DIPs, which are collectively subsumed by the overall ORHAP-DIP.

The core of the ORHAP is a DIP that contains the provision for actually carrying out the activities

Efficient implementation of the ORHAP demands that all parties involved (AMCs, subregional groupings, ASEAN itself, and the international agencies concerned) have access at all times to the entire list of actions being or to be undertaken under the ORHAP.

Thus a "working" version of the ORHAP-DIP used by authorized members is the continuously updated, online, intranet version. The online up-to-date version of the RHAP at a particular point can be obtained as a printout.

The DIP Matrix

The format used for presenting the ORHAP-DIP is that of a matrix, in which each of the variables identified above appears as a column heading. Each action, along with the information corresponding to variables, appears as one row of the ORHAP-DIP matrix, referred to as an "action line."

All updates and changes to a particular portion of the DIP are received by the CSU via the ORHAP intranet. CSU then updates the master ORHAP-DIP, and immediately places it on the intranet, making it available to all authorized persons. While monitoring the implementation of the ORHAP-DIP is ultimately the responsibility of the HTTF, any user with ORHAP intranet access can monitor implementation at will, and can (via HTTF representatives) raise implementation issues at meetings of HTTF. Donor organizations can use the ORHAP-DIP matrix to determine how their contribution could complement ongoing or planned actions by AMCs or other donors, based on the amount of their financial contributions serving as a rough proxy for the scope and coverage of the various actions.

In the case of donor-funded projects, the donor agency itself is the organization responsible for ensuring that the project activities and related actions are fulfilled

Moreover, any particular country, subregional body, or donor organization can specify an action that it has decided to undertake in support of the ORHAP and the six-year program. As long as the other relevant information is also specified, and the desire to have this action included in the ORHAP-DIP is communicated to HTTF, then this information will be inserted as an action line into the ORHAP-DIP matrix in the appropriate section. This action line becomes, in essence, a "contract" or a promise to undertake the particular action, during the time frame specified, with the organization and person named being responsible to see that action through to completion. All other persons or bodies with intranet access to the ORHAP-DIP matrix will then be made immediately aware of the commitment to undertake this action.

The computer software used to manage the ORHAP-DIP matrix gives all users with intranet access to the ORHAP-DIP the ability to sort out action lines by any variable they wish. For example, any user could query the matrix for actions that have not been undertaken within a time frame specified. The system would then return a list of all actions from all sections of the ORHAP-DIP that fulfill this condition.

Organic Link between ORHAP and DIP

All of the details of the individual actions contained in the DIP are summarized in the Operational Plan for Implementing RHAP. This short, written summary is convenient for HTTF and AMMH since it states, in an abbreviated form, the core initiatives that ASEAN itself is to undertake.

For example, one of these core initiatives is the formulation of FSMPs for the two SRFAs. Successfully completing this initiative will require many actions (e.g., negotiation of international agreements, deciding how personnel and equipment are to be mobilized, who pays for the mobilization and demobilization, etc.). All of these actions for successfully completing this initiative are contained in the SRFA-level DIPs. Each of the actions must be implemented by a particular agency or organization. Each action has a cost estimate associated with it; so it must have an identified source of funding. Each action also must have attached to it a monitoring variable. However, in order to be able to manage all of this at HTTF and AMMH meetings, an abbreviated (and aggregated) statement at the core initiative level was required. This is the Operational Plan for Implementing RHAP.

In the case of donor-funded projects, the donor agency itself is the organization responsible for ensuring that the project activities and related actions are fulfilled.

Actions to be undertaken by the donors that support implementation of the ORHAP are therefore treated in exactly the same way as actions to be performed by ASEAN or the national governments. Since the DIP is segregated into prevention, mitigation, and monitoring, each donor action is inserted into the section of the DIP that corresponds to the particular ORHAP component to which it relates.

Monitoring and Evaluation of ORHAP Implementation

The main objective of monitoring and evaluation is to refine the implementation of plans, projects, and activities. While monitoring shows achievements and failures, evaluation goes into the contributing factors or causes and how the problems can be solved. It thus provides an efficient feedback loop for improving and upgrading the systems and procedures of implementation. Evaluation is a simultaneous process to analyze the factors that had contributed to the monitored outcome. It is designed to trigger management action at critical points.

Monitoring and evaluation is associated with specified C&Is (e.g., of sustainable forest management). C&Is provide standards to judge (as well as ways to measure) the performance and progress toward achieving the stated goals. Apart from helping to judge the results, quantitatively and qualitatively, C&Is practically serve to enhance the design of program components and actions, adding a new dimension to strategic planning.

Status of ORHAP Implementation

In order to provide the greatest chance of successful preparation for future fires and haze, regardless of when they occur, the ORHAP will remain a continuing process. While the ORHAP document, and even some of its conceptual content, may undergo changes, its implementation can proceed uninterruptedly via the ORHAP-DIP. Based on the experience of about the first two years, it is possible to give an interim report on the progress of the ORHAP, and to give some idea of the direction it will take in the future.

Overall, the progress achieved has been substantial. The scope and range of collaborative activities is impressive. However, progress has been uneven across the ORHAP's three programs (prevention, mitigation, and monitoring) and their components.

Uneven Progress

By far, progress has been the most rapid in the program components of monitoring, in part because this has been a major focus of donor initiatives. Progress in the prevention program has been less rapid, and mitigation has lagged behind prevention.

This outcome was to be expected. Given the centralized and relatively technology-intensive nature of monitoring, as well as the donor support for this component, it was clear from the beginning that this program would progress quickly. The magnitude of the task of implementing the mitigation program is much greater, given that this requires formulating and implementing FSMPs at the national and regional levels. It was also expected that prevention would unfold at a slower pace than monitoring, as this needs a somewhat more flexible timescale, and in some cases would require radical policy shifts that are impossible to achieve in the short run.

Once this unevenness in the progress of implementation became apparent, HTTF and AMMH took swift action. Since members of both these bodies are drawn solely from national-level environment ministries, an immediate priority was to expand the pool of

Progress has been the most rapid in the program components of monitoring, in part because this has been a major focus of donor initiatives. Progress in the prevention program has been less rapid, and mitigation has lagged behind prevention

A study to determine the feasibility, purpose, concept, and alternative financing vehicles to establish an ASEAN Haze Fund was carried out under ADB's RETA Project

prevention and mitigation expertise available to both bodies. This is being achieved by the creation of a panel of national experts in prevention and mitigation who will work with, and advise, their respective HTTF and AMMH members in accelerating the pace of progress in the implementation of these programs.

ASEAN Haze Fund to Implement the ORHAP

A study to determine the feasibility, purpose, concept, and alternative financing vehicles to establish an ASEAN Haze Fund was carried out under ADB's RETA Project. It also identified various management and institutional arrangements, including operational guidelines. The study concluded that the creation of the ASEAN Haze Fund is not only feasible, but urgent in order to finance ORHAP-related activities, particularly fire suppression and mitigation operations. This can be conducted through a cohesive and integrated framework, drawing on the resources of AMCs and other sources of funding.

Purpose of the Fund

The main purpose of the fund is to provide quick and emergency access to a pool of funds that will enable AMCs to implement their FSMPs to suppress forest fires that result in, or threaten to create, a significant degree of transboundary haze.

This assumes efficient, effective, and cost-effective FSMPs and SRFAs. In the medium to longer term, the fund could be used for upgrading FSMPs, preventive measures, and monitoring, when the level of its resources have increased over time.

Guidelines on trigger levels would need to be created in order to invoke access to the fund. Factors to be taken into account include air pollution indexes, FDRSs, haze transport modeling, and size and location of affected areas. Constant monitoring should be emphasized for early and less costly action.

Conceptual Options

The study has identified two conceptual options for consideration. Elements in Option A include equal contribution from AMCs; funds to be provided to the requesting transboundary haze source country; and periodic contributions from AMCs to replenish the fund.

Elements in Option B include AMCs' contribution to the fund varying according to risk; part of the funds provided to the transboundary haze source country for fire suppression operations to be returned, interest-free; private polluters should be made liable for their acts; and where necessary AMCs will be required to replenish the fund.

Other Proposed Features

The study has proposed measures for expanding the financial sources of the fund (e.g., linking it to ASEAN economic schemes, obtaining company sponsorships and contributions from private interests, and inviting donor [dialogue partner] contributions). The study also has provided suggestions for fund management, including institutional arrangements, procedures for invoking the use of the fund, expenditure and financial guidelines, and investment guidelines.

Consideration of, and a decision on, the haze fund proposed in the study is pending.

Information Management

An effective information system is an open-ended system, with continuous add-on capability. The system, depending on its nature and scope, can vary from simple and crude methods to highly sophisticated ones involving computer networks, the Internet, and web sites with the capability of online information exchange and updating facilities. Still, those near the fires in comparatively underdeveloped areas often do not have access to such new systems of communication.

Some of the important problems relating to fire information management identified during the1997-1998 fires and haze are as follows:

- data are spread out in various institutions that are often reluctant to provide information. If available, data are not in compatible format, are of low quality, and expensive;
- data cannot be communicated in time when needed because telecommunications are not adequate;
- reliable human resources to gather and process data are limited. Data on the 1997-1998 fires were mostly monitored by three foreign-funded satellite-monitoring projects operated by foreign experts; and
- data processing was not adequate to produce information to support fire management.

Assessment of the Information System

The information system involves several interrelated actions to deliver the required data to the users: data collection and generation, processing and analysis, development of useful information, updating of information, communication, and dissemination.

ADB Study on Information Management Systems

ADB's RETA Project, as part of its TOR, carried out a Study on Assessment of Information Management Systems on Forest Fire and Transboundary Atmospheric Pollution at the ASEAN Secretariat and Related ASEAN Institutions. A key objective of the study was to assess the information network of the ORHAP, and to recommend an appropriate information management system.

The study conducted several activities.

- Reviewed available documentation related to fires and haze in the ASEAN Secretariat.
- Reviewed the types of data and information collected by the ASEAN Secretariat.
- Established categorization of the information to be included in the Internet and intranet site structure.
- Reviewed data processing and dissemination procedures in the ASEAN Secretariat's units.
- Assessed the information flow in and between relevant ASEAN bodies and the ASEAN Secretariat.
- Assessed the institutional capacity and functional skills required for fire and haze data collection, processing, and dissemination.
- Assessed the facilities (including hardware and software) for fire and haze data collection, processing, and dissemination.
- Assessed the ASEAN Secretariat's relationship and coordination activities with other institutions.

Apart from the assessment of fire- and haze-related information management systems (IMS), the output of the study included other assessments such as establishment of the public-access web site; formulation and implementation of training programs for staff in the use and maintenance of the web site; a restricted-access intranet for parties directly associated with implementing the ORHAP; and staff training programs.

Information Management Capability of NMS

The NMS have varying capacities to carry out collection, processing, and dissemination

Data processing was not adequate to produce information to support fire management

of information on fires and transboundary haze. Basically each NMS is responsible for collecting fire and haze data in their own country. Capability in this regard varies from country to country.

During the 1997-1998 ENSO-induced drought, NMS played a limited though critical role in the response and management of the regional and national smoke and haze problem. They contributed through: (i) weather monitoring and forecasting; (ii) monitoring and surveillance, including hot spot identification using satellite imageries, haze trajectory modeling, compiling monthly and seasonal climate prediction information, and activities related to air quality monitoring; and (iii) effective and prompt dissemination of information to environmental and other agencies engaged in fire and haze response and management, and to the public, through the Internet and news releases.

The NMS' capacities need to be strengthened to better provide timely warnings and forecasts to anticipate the risks of fire and haze, and assist decision makers in taking appropriate action.

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Information Management Function of HTTFs and SRFAs

The HTTFs of Indonesia, Malaysia, and Singapore and SRFAs do not yet have a clearly defined information management function; nor are formalized or nonformalized referenced data sets maintained.

At the regional level, inventories and assessments of fire management and suppression capability were carried out under the auspices of the ORHAP, initially to establish a benchmark.

These are to be repeated periodically, to keep HTTF and AMMH abreast of any changes in a particular AMC's fire management capacity. The results of the assessments, as well as updates will be posted on the restricted-access intranet, which will be maintained by CSU.

ASEAN Specialized Meteorological Centre

The ASMC has been designated as a regional information center for compiling, analyzing, and disseminating information derived from satellite imagery and weather data necessary to detect and monitor land and forest fires and the occurrence of smoke and haze. In line with this, ASMC operates an intranet for NMS to access fire and haze products. The products available on the intranet include trajectory forecasts, regional climate forecasts, latest hot spot maps and satellite data, latest forecast of winds, visibility information, air quality, and haze analyses. Other information services generated by ASMC for the ORHAP consist of its periodic reports to the HTTF and SRFA meetings.

Role of the ASEAN Computer Unit

While the computer unit of the ASEAN Secretariat does not operate and maintain fire-and-haze related information management systems per se, its resources and infrastructure are an essential vehicle in internal communications, given the LAN's broadcasting and messaging abilities.

In addition, Internet technologies such as E-mail and web development tools are expanding the communication potential beyond the LAN. To this end, the computer unit jointly manages the ASEAN web site with the office of the Secretary-General.

Information Flow Analysis

An analysis of the current information flows, products, and services revealed several issues that will require attention in establishing an integrated IMS. These include the following.

- The processing of cross-sectoral information products in the ASEAN Secretariat needs strengthening. ASEAN-wide information flows run vertically and are highly sectoral. Within the ASEAN Secretariat, the units responsible for processing cross-sectoral flows of internal information are: (i) Public Information Unit of Office of the Secretary-General (OSG); (ii) the Library and Publications Unit; (iii) the Culture and Information Unit; and (iv) the Computer Unit. Together these units comprise the internal ASEAN Secretariat "Information Nexus," or key points in the information flow that provide value-added processing of various information products. However, no unit has a clear role in assigning priority to cross-sectoral information, largely due to the absence of a clear information strategy. There is thus a need to better define roles and responsibilities of the units to optimize public information activities. There is also scope for tightening this arrangement either by designating a central unit or reducing the number of units involved in processing information.
- There is a lack of consistency in the maintenance of data sets. The data sets maintained by each ASEAN Secretariat unit are largely limited to decisions of sectoral meetings and project implementation status. Further, the data sets are maintained in different and sometimes incompatible electronic formats. The introduction of a universal data model for the data set should be explored to provide consistency, ease of accessing, and to facilitate database management.
- There is a need for an ASEAN Secretariat Communications and Information Plan. The ASEAN Secretariat can develop information materials and communicate to the public through news releases. However, this capacity should be supplemented with an ability to develop effective communications and strategic plans to assist the appropriate units, particularly those comprising the information nexus, in more effectively making use of information services and resources.

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Other Findings of the Study

Several findings and issues emerged during the ADB study on information management system, relating to forest fires and transboundary haze pollution.

- *Scattered Information Resources on Fires and Haze*. The current ORHAP information management system is comprised of discrete and largely independent information subsystems that predominantly address service-oriented functions and inadequately address the other information management functions, i.e., planning and policy, and regulatory and technical aspects.
- *Fire-and-Haze Policy and Planning Information System required*. There is a need for an integrated information management system to address the policy, planning, and program development functions of the ORHAP implementation. The targeted users for such a system would be AMME, AMMH, and ASOEN. Similarly, a database on fire-and-haze-related international and regional agreements and protocols would greatly help in carrying out the ORHAP. HTTF and the Asia-Pacific Centre for Environmental Law (APCEL) would be the main beneficiary of such a system.

> There is a need for a centralized regulatory and technical service information system for the ORHAP to help in the activation of emergency response and mobilization systems, including monitoring of the DIPs

Currently, the management and supervisory levels of the ORHAP rely almost entirely on information compiled and collected by the respective national agencies.

- *Emergency Response Mobilization Information System required.* There is a need for a centralized regulatory and technical service information system for the ORHAP to help in the activation of emergency response and mobilization systems, including monitoring of the DIPs. The targeted users would be the HTTF Chairperson; the HTTF member countries; the lead countries responsible for ORHAP's prevention; mitigation, and monitoring components; and collaborative partners.
- *Programs and Projects Information required.* A database of programs and projects of regional and national initiatives, including those supported and catalyzed through collaborative partnerships, is an important requirement for the ORHAP. The establishment of a data set on haze programs and projects is required to work in conjunction with a database on DIPs.
- *ORHAP Information System on Supporting Services required.* There is a need for an information system that addresses the areas of technical services and support. Such a system would incorporate the firefighting, training, and public awareness programs and activities. The end-users for such systems would be ASMC, the ASEAN Regional Research and Training Center for Land and Forest Fire Management in Palangkaraya, national firefighting services, and public information agencies.
- *Institutional Cross-Sectoral Coordination Mechanism needed.* Several ASEAN bodies are undertaking initiatives that have potential impact on policy, planning, and program development of ORHAP implementation. Therefore, there is a need to develop a mechanism to monitor cross-sectoral activities to ensure internal consistency, particularly in ASEAN approaches to agriculture, forestry, culture, and information areas. HTTF and the ASEAN Secretariat would be the principal end-users for such a system.
- *Need for an Integrated Fire-and-Haze Corporate Data Model.* Each substantive unit in the ASEAN Secretariat possesses its own project database system, which uses standard, off-the-shelf software such as Microsoft Word and Access. There is, however, no standardized corporate data model for such critical information. The resulting disparate data sets and database management systems therefore require rationalization and integration.
- *Need for an ASEAN Secretariat Fire-and-Haze Information Strategy.* The flow of information resources among the substantive units within the ASEAN Secretariat should be strengthened. This may be done through the introduction of an information management strategy on fire-and-haze data collection and dissemination. As a first step, further integration of information resources would be improved by coordinating and synchronizing the development of related database management systems. There is also a need to closely follow reorganization and restructuring plans at the ASEAN Secretariat as these may affect units handling fire-and-haze information.

ORHAP Information Systems Architecture

The study on IMS by ADB's RETA Project identified four broad categories of information management functions: (i) policy, planning, and program development; (ii) regulatory and technical services; (iii) administrative services and support; and (iv) internal information management, which together formed the ORHAP information systems architecture.

The purpose was to summarize the information packages and database to support these broad categories and their information management functions.

These information databases were developed and integrated into the ORHAP information management system—the ASEAN Haze Action Online Internet and intranet systems. Through the ASEAN Haze Action Online web site these information databases can be exchanged and disseminated among ORHAP institutions and the public.

Information Packages and Databases

The information packages provided below are arranged according to information system architecture given above.

Policy, Planning, and Program Development

The databases that support this information management function are as follows:

ORHAP/SRFA/NHAP Status Monitoring System. This information system is a higher-level search and query engine (index server) that accesses all the other information systems in the ASEAN Haze Action Online Internet and intranet web site (see Appendix 6). Data maintenance of the site index is performed automatically by the index server as soon as new data are added to the system.

Detailed Implementation Plan Information System. This information system manages the entire DIP data set at ORHAP, SRFA, and NHAP levels. This system fulfills the need for an ORHAP monitoring system since information concerning the status of actions at each of the DIP levels will be continuously available. The data maintenance of the DIP information system is assigned to the respective focal points, designated bodies, and personnel assigned by ORHAP institutions responsible for carrying out a specific action. DIPs will be periodically published and distributed separately as hard copy.

Collaborative Partnerships Program and Projects Information System. This information system provides the vehicle to manage information on all funding agency, NGO, and private sector programs and projects, and is a tool to better coordinate development assistance by matching specific needs to assistance priorities. A full range of functions—searching, querying, reporting—is available for planning, implementation, and monitoring of funding agency-assisted projects. The maintenance of this database will be assigned to the respective funding agency (along with the CSU) and the coordinator of the assistance project.

Agreement and Protocol Monitoring System. The Document Center Database System maintains the data set on agreements and protocols to enable ORHAP implementation. Data maintenance of this information system will be carried out by CSU at the ASEAN Secretariat.

Regulatory and Technical Services

The functions of the ASEAN-CSU under the ORHAP include management of technical services and support relating to the ORHAP, SRFAs, and NHAP-DIPs. An important function is servicing and maintaining the fire-and-haze Information Clearinghouse, and maintaining the Internet and intranet. The tasks also include reviewing, analyzing, and processing information from fire-and-haze related web sites for possible incorporation into the ASEAN Fire and Haze web site (see Appendix 6). This

DIPs will be periodically published and distributed separately as hard copy

ORHAP information management function would require the following information systems:

Mobilization and Response Information System. This system is intended to help maintain information and data sets on field-level fire suppression, in particular on facilitating the formulation of FSMP documents, maintaining the detailed inventory and tracking system, and formulation of the TEWT, in conjunction with the Firefighting Resources Inventory Tracking System. Data maintenance of the system is carried out by CSU. Future development of the system will include a status tracking system to monitor FSMP in each of the targeted regions and subregions.

Administrative Services and Support

The functions under this category include: ORHAP monitoring support to, and secretariat support for, the HTTF; recording and documenting haze-related meetings; maintaining and updating the regional inventory of fire management capability; and monitoring the regional fire-and-haze response system. This ORHAP information management function would require the following information systems:

Firefighting Resources Inventory Tracking System. This information system contains the data set on the firefighting suppression personnel, and suppression and communications equipment. This system will keep track of the fire suppression resources at the regional, subregional, national, and provincial levels. The firefighting agencies at the national and subregional levels will be responsible for keeping this database up-to-date.

Contact Information System. The ASEAN Haze Action Online Contact information Database maintains data of all persons and institutions concerned with ORHAP implementation. This database is maintained by CSU.

The ASEAN Haze Action Online Contact information Database maintains data of all persons and institutions concerned with ORHAP implementation

ASMC and NMS Information System. The IMS of the ORHAP would require a linkage with key information and dissemination activities carried out by the ASMC and affiliated NMSs. This linkage is available in the Monitoring Section of the ASEAN Haze Action Online web site. At present, this section contains hyperlinks to the web sites of various institutions specializing in monitoring of fires and haze (see Box 15). Hyperlinks/linkages in this section are maintained by CSU.

Training and Skills Information System. An information system on training and skills of prevention, suppression, and monitoring personnel would be required to indicate the capacity of regional human resources. This system is implemented in the ASEAN Haze Action Online—Firefighting Resource Inventory System, Document Center, and Calendar. The Firefighting Resource Inventory System keeps track of firefighting personnel with the skill level information; the Document Center maintains the available training and skills documentation; and the Calendar System provides the schedule and venue of all past, present, and future training activities.

Internal Information Management

The system is concerned with information management functions, which are internal to ORHAP implementation. These include:

AMME/AMMH and HTTF/SRFA Decisions and Report Tracking System. The ORHAP IMS should also provide the means to maintain, archive, and access decisions and reports by AMME, AMMH, HTTF, and SRFA. This system is incorporated in the ASEAN Haze Action Online Document Center Module that keeps track of all reports produced by ORHAP institutions and meetings. CSU carries out data maintenance of the Document Center.

General Documentation and Reference System. The ORHAP's IMS also comprises an information system that maintains other documentation and referencing required for ORHAP implementation. This system is also incorporated in the ASEAN Haze Action Online Document Center that keeps track of all documentation and referencing required for ORHAP implementation.

Data maintenance of the Document Center is carried out by CSU.

Regional Information Center and Clearinghouse

Based on the assessment of the IMS, a regional information center and clearinghouse was established at the ASEAN Secretariat. It includes: real-time satellite imagery; a continuously-updated inventory of relevant funding agency-assisted initiatives; information on past, present, and future meetings, workshops, seminars, and training programs relating to transboundary haze; and numerous other features.

BOX 15 **Some Important Fire and Haze Web Sites**

- http://www.unifreiburg.de/fireglobe
- http://smd.mega.net.id/iffm
- http://www.neotecinc.com/wildfire
- http://www.mpch-mainz.mpg.de/~bibex
- http://www.iffm.or.id/>
- http://www.mtv.sai.jrc.it/projects/fire
- http://modarch.gsfc.nasa.gov/fireatlas/fires.html
- http://www.anu.edu.au/Forestry/fire/firenet.html

Training programs in the operation and maintenance of the public-access web sites were formulated and conducted by RETA 5778. Trainees included ASEAN Secretariat staff who would maintain the web site's content, as well as staff from the Secretariat's Computer Unit, who would be responsible for integrating the web site into the ASEAN Secretariat's overall network of computer users. Separate training programs were conducted for staff who support the work of HTTF members to ensure that the latter would have continuous access to the information posted on the ORHAP intranet.

Notes

29 ADTA INO 2999: *Planning for Fire Prevention and Drought Management*, 1998.

30 The application of market-based instruments to environmental issues was originally developed to address problems such as pollution and traffic congestion. The intention is to use the market system to reduce negative factors or social cost. A tradable pollution permit is a market-based instrument.

31 The factors determining the choice of technique are (i) terrain and topographical features, and (ii) the crop involved. The techniques in use in the region are the windrow method, the skyline method, and the bunching method. *In situ* chipping and accelerated decomposition are technically feasible, but financially not yet viable.

32 ADTA INO 2999: *Planning for Fire Prevention and Drought Management*, 1998.

33 Phase I of the Immediate Action Plan—Field Training Exercise for Prevention and Control of Land and Forest Fire and Haze in Riau Province, Sumatra (1999/2000), funded by UNEP is ongoing.

In addition the MOU for Immediate Action Plan—Field Training Exercise for Prevention and Control of Land and Forest Fire and Haze in West Kalimantan, (2000/2001) between ASEAN and Australia was signed on 28 January 2000 at the ASEAN Secretariat, Jakarta. The Field Training Exercise is designed to assist local government officers and the community in West Kalimantan, Indonesia, to develop a comprehensive action plan for forest fire management and their capacity in forest firefighting. It also aims to monitor forest fires to prevent them from getting out of control during the dry season and to develop a Fire Suppression Mobilization Plan in West Kalimantan. Australia's contribution is $173,000. BAPEDAL will implement the monitoring and prevention components, while MOFEC will develop the mitigation component. RHAP-CSU of the ASEAN Secretariat will serve as the coordinator for the project.

Riau and West Kalimantan are regarded as the first priority areas. Similar Field Training Exercises will also be conducted for other haze-prone areas in Sumatra and Kalimantan.

34 The two SRFAs currently in place are SRFA Sumatra, whose membership comprises Indonesia (lead country), Malaysia, and Singapore; and SRFA Borneo, whose membership comprises Brunei Darussalam (lead country), Indonesia, and Malaysia. The idea of forming a third SRFA for the Greater Mekong subregion (SRFA-GMS) has been mooted. SRFA-GMS has yet to be officially formed, because the impetus for this (i.e., extensive large-scale fires within the GMS) has not yet arisen. SRFA-GMS would group all ASEAN member countries through which the Mekong River flows (Cambodia, the Lao PDR, Myanmar, Thailand, and Viet Nam). Its formation would leave the Philippines as the only ASEAN country not a member of an SRFA. This deficiency could easily be repaired by the Philippines joining SRFA Borneo, which would be fitting, due to the Philippines' geographic proximity to the island of Borneo.

35 The best case time frame required for completing an individual FSMP exercise is 18-24 months (Appendix 3).

36 In East Kalimantan alone, where it has been estimated that some 95,000 ha of industrial plantations were burned in the 1997-1998 fires, replanting costs have been estimated

to be around $20 million (personal communication from Alastair Fraser, 10 September 1998).

37 The TAO array consists of about 70 buoys in the tropical Pacific Ocean, measuring oceanographic and meteorological data in real-time via the Argos satellite system.

38 The objectives of the GCOS program of WMO include providing the data required to meet the needs of the climate system monitoring, climate change detection, research toward improved understanding, and modeling and prediction of the climate system.

39 Lyons and Weber (1991) developed a simple burning test to estimate fuel moisture. The test consists of lighting a single dead leaf or pine needle, etc., representative of the fuel that will burn. The leaf is held horizontally to be ignited and then pointed down or up until the extinguishment angle is found. This test is repeated a few times to obtain representative results and the fuel moisture is related to the angle. Such a simple test if shown to be valid would be cheap and could be easily conducted by landholders and forest rangers.

40 Canada is also considering another project, a "Fire Danger Rating System for Indonesia: An Adaptation of the Canadian Fire Behaviour Prediction System." It will be an important contribution toward improving the basic knowledge on weather-fuel-fire and fire behavior relationships.

41 Dryness maps can be easily and inexpensively prepared from rainfall data. The rainfall debt index uses the deficit between average and current rainfall levels as the sole variable for assessing the risk of fire.

42 It may also be possible to reduce the cost of aerial surveillance by using ultralight aircraft in some circumstances. The advantages of this approach are low operating and maintenance costs, and the fact that such aircraft may be able to be manufactured locally. The greatest disadvantage of ultralight aircraft is their low average airspeed, which lengthens the flight time of patrols relative to faster, more costly aircraft. In some ASEAN countries, government regulations require that aircraft used for aerial surveillance be powered by a minimum of two engines. This effectively rules out the possibility of using ultralight aircraft for aerial surveillance, since virtually all of them are powered by a single engine.

43 Particulate conversion ratio (PCR) is the proportion of fuel mass that becomes total suspended particulates. The ratio is often measured by the relationship: PCR = 1.83 c/d, where 1.83 represents the constant that relates to the carbon content of the fuel that is converted to carbon dioxide, *c* is the mass of carbon dioxide in 1 m^3, and *d* the mass of total suspended particulates in 1 m^3.

44 CO/CO_2 Ratio: The ratio CO/CO_2 provides information about the nature of the combustion generating haze. For example, if the ratio is 0.04, it is considered that flaming combustion is involved. If the ratio is 0.25 then smoldering combustion is involved.

45 A meteorological instrument using transmitted and reflected laser light for detecting atmospheric particles and pollutants.

46 An appropriate index for use in the region is the Normalized Difference Vegetation Index (NDVI), which is derived from a simple formula that uses data generated from two satellite channels, one that records infrared (i.e., heat) information, the other

recording light (i.e., visual) information. The NDVI provides a crude estimate of vegetation health, which makes it an appropriate means of monitoring changes in vegetation health and cover over time. NDVI is considered the most appropriate for the AMCs, given the recurrent nature of fires and haze in the region.

47 Haze transport modeling relates to numerous issues in addition to the movements of haze pollution such as the likely composition of the haze when it arrives at a particular predicted destination point. Haze transport modeling thus encompasses the formation, movement, and dispersion of haze pollution, as well as its chemical composition and density, both of which determine its human health impacts.

48 Component I of PARTS is being funded by the Australian Government. Components 2 and 3 are being funded by the US Government under two of the 10 subprojects that compromise SEA-EI.

49 The purpose of WMO's Global Atmospheric Watch program is to provide data, scientific assessments, and other information on the atmospheric composition and related physical characteristics of the background atmosphere from all parts of the globe. The measurement program includes: greenhouse gases, ozone, radiation and optical depth, precipitation chemistry, chemical and physical properties of aerosols, reactive gases, radionuclides, and related meteorological parameters.

50 Hard-law international instruments are legally binding in that they include provisions for sanctions (e.g., trade boycotts or monetary compensation) in the event they are contravened. Soft-law international instruments such as principles and declarations include no such provisions. Their purpose is simply to formally state the intent on the part of the signatories to take concerted action toward a mutually agreed goal at some point in the future.

51 While NHAPs form part of the overall system of the ORHAP, the responsibility for their formulation rests with the respective national governments.

CHAPTER 6

The Way Ahead

[This chapter looks into the important actions required to consolidate the initiatives so far undertaken and to promote appropriate forest fire management in the ASEAN region, to support rational land use and development.]

Introduction

Having formulated the ORHAP for ASEAN, covering the period 1999-2005, one might assume that the way ahead is clear and effortless; and what is required is to carry out the activities listed under prevention, mitigation, and monitoring programs, as far as possible.

The situation is not that simple or straightforward. The concept of the RHAP was formally approved by AMMH in December 1997; and the ASEAN/ADB efforts to put the RHAP into operation through the ADB-funded RETA Project continued from April 1998 to December 1999.

The RETA Project registered significant achievements, in the short term, most of which are of a startup nature. It calls for a considerable amount of work to consolidate the gains and to institutionalize a system in order to sustain development.

Firm action will be needed to prevent a recurrence of the fires and haze-producing smoke from the 1997 conflagration in Indonesia.

Photo: Integrated Forest Fire Management Project, Indonesia (Courtesy: Ludwig Schindler)

The Way to be Negotiated

The path to be negotiated toward achieving the objectives of the RHAP, i.e., an effective and efficient system of fire and haze management in the region, is not easy or clear of hurdles. Most of the assumptions relating to infrastructure, institutions, and institutional instruments would require enormous effort and investment to materialize.

The ORHAP, for now, having been defined for a period of only six years, represents the first (or the first few) steps of a long journey. To start implementing the ORHAP and carry it forward as long as is required through all the imaginable constraints would require constant, consistent, and cooperative efforts by the involved parties and partners—national, regional, and international.

The Transition

The DIPs have given details about the activities to be carried out under expected core funding from ASEAN and AMCs, donor assistance catalyzed by ADB's RETA Project, and other sources, as well as areas where there are funding gaps. Timely mobilization of resources from all sources is vital if the ORHAP is to show positive results.

The RETA Project has been formally terminated and the onus for carrying forward the implementation of the ORHAP now rests with CSU. However, it was agreed the RETA Project would fund some actions to promote a smooth transition. These include (i) $50,000 for implementation of the IAP Field Training Exercise for Prevention and Control of Land and Forest Fire and Haze in Sumatra, Phase 2 (Phase 1 at an estimated cost of $50,000 was funded by UNEP); (ii) Support to the ASEAN Regional Haze Fund Study, estimated to cost about $20,000; and (iii) a feasibility study for an ASEAN Agreement on Transboundary Haze Pollution, to be cofinanced with UNEP and other donors.

To obtain a better vision of what is to be carried out, it is useful to go over some of the relevant lessons from past experience.

Lessons and Experience

The land and forest fires that ravaged large areas of Sumatra and Kalimantan in 1997-1998 added a new urgency to the issue of forest fire prevention and management, because this was the fifth time in 15 years for such an occurrence. The emergency caused by the forest fires and the associated transboundary haze problem is for the time being over. The damage and negative impacts caused were considerable and their scars remain. Investigations carried out so far on the underlying causes, consequences, and constraints provide reasonable insight into the serious lapses of the past and the potential fire threat looming over the future. Actions are urgently required to avoid not only further recurrence of the devastation from forest fires, but also the complacency and lack of compliance with regulations in the past.

Multidisciplinary investigations on the different aspects of forest fires and haze worldwide have confirmed that concerns about the global impact of forest fires, in the form of transboundary pollution, climate change, and loss of biodiversity, are very real.

Being prepared for future forest fires and haze should consist of a balanced package of measures to prevent unwanted fires, to control and suppress fires when they occur, to monitor all developments relating to fires (including predisposing, feeding, impact-generating, and post-event factors), and to establish an effective institutional mechanism to manage the package.

An all-embracing lesson from the last 20 years of experience with forest fires and haze is that the combined effects of causes, constraints, and contributory factors tend to come together and conquer, unless an adequate defense force (a combination of policies, strategies, systems, technology, and human resources) is maintained in prime condition to provide readiness.

Actions are urgently required to avoid not only further recurrence of the devastation from forest fires, but also the complacency and lack of compliance with regulations in the past

General Lessons

The weaknesses and failures identified each time fires and haze occur in the region resurface again and again—followed by resumption of abandoned remedial attempts that will be later discarded yet again. Can we expect that there will be a change in the “touch-and-go” trend? Will there be drastic action to address the weaknesses and failures, and an institutional system (instruments, organizations, coordination mechanisms) to carry it through in a sustainable manner? As long as there is inadequate understanding and appreciation of decision makers about (i) the impacts of fires and haze on society, economy, and the environment; and (ii) the positive relationship of the benefit of the disaster averted to the cost involved in fire and haze management, it will be difficult to maintain a sustained assault.

The urge to make private gains by flouting the policies and regulations relating to land clearance has been found to be an important

If there is no effective, efficient, and impartial enforcement mechanism, policies and regulations will not be of much use in addressing fires and haze

factor in the spread of fires. If there is no effective, efficient, and impartial enforcement mechanism, policies and regulations will not be of much use in addressing fires and haze.

An assumption that past failures will not be repeated in the future needs to be based on firm and timely action to remove the institutional, social, cultural, and other factors that have led to failure.

Globally, there is a trend of shrinking government budgets for forest protection, while many nations are not able to support a well-functioning fire management organization. The standards required by the initial agreements of IDNDR are not met in most signatory countries. Can they be in the future? International sharing of fire management expertise and resources may provide a solution, at the same time demonstrating solidarity among nations to protect forest and other vegetation resources. There is considerable international interest to address the situation that needs to be channeled in a coordinated manner. More than seeking financial grants and material support from donors, mechanisms for appropriate and sustained international collaboration and with a long-range perspective need to be established and maintained.

Specific Lessons

Regional collaboration and sharing of resources across national boundaries (e.g., in SRFAs) to address forest fires and haze have been accepted, in principle, as a feasible and efficient approach. In the outbreaks of 1997-1998, and in the pilot trial runs later in Sumatra, it has become evident that there are several practical problems covering legal, procedural, logistic, and diplomatic aspects, involving institutions representing different sectors. Legal agreements are essential to ensure smooth functioning of joint activities, including:

- harmonization of air pollution indexes;
- standardization and enhancement of fire management training curricula;
- immigration and customs preclearance procedures for cross-border sharing of fire suppression personnel and equipment;
- supranational administrative arrangements and joint firefighting teams;
- data sharing among weather monitoring agencies; and
- access to the airspace of neighboring countries for aerial surveillance of fires to determine optimal fire suppression strategies.

These should be addressed thoroughly, systematically, and expeditiously.

It is to be underlined that, formal agreements apart, the pervading spirit of cooperation is an attitudinal development that comes through continuous attunement.

Even within countries, policy and institutional changes are slow to emerge and slower still to be put into practice, unless there is adequate political will to see them through. Earlier, the need for several policy changes was highlighted, such as introducing market-based instruments for promoting mechanical land clearing. These are of vital importance. Inaction due to a lack of political will can lead to serious consequences.

Transboundary haze pollution in the ASEAN region is primarily caused by large land-clearing fires deliberately set by commercial scale companies and others. Experience from ADB's RETA Project suggests that this causes smallholders, individuals, and community groups to often develop a sense of acceptance of periodic haze caused by large-scale land clearing, since they feel powerless to alter such occurrences. Integrating public awareness programs into the FSMP exercise can help to empower these persons and groups, rather than simply providing them with additional information, as long as they are complemented by relevant policies and systems favoring rational land tenure and land use. Without willing participation of the people, public policies and programs cannot succeed in achieving the objectives.

Policy conflicts within countries are often reflected at the regional level through their impacts. For example, land use in many countries, historically, has been rife with conflicts—putting individuals, families, communities, and resource users constantly at loggerheads with each other and creating an atmosphere of hostility, social tension, and unsocial acts. Conflict resolution based on equity and fairness should be a necessary component of any program associated with resource use and management.

The RETA Project has pointed out two aspects that need to be assigned priority if the region is to have sufficient capacity to alter the level of transboundary haze pollution during subsequent ENSOs.

First, the process of implementing FSMPs for the most haze-prone areas of the region must be brought soon to fruition. This involves far more than formulation of FSMP documents. It encompasses building fire management capacity at the community through district levels to which ASEAN- and donor-provided fire suppression resources can link. The impact of other activities such as ground surveillance and monitoring would also be magnified by their being directly integrated into the FSMP exercise.

Second, the need to adequately meet the challenge of formulation and implementation of the FSMPs for the SRFAs is urgent. The experience so far in cooperative fire suppression initiatives in the region is that most of the concrete details on how to carry them out (e.g., the extent of assistance, how regional assistance is to be financed, and the responsibilities of the providing and the receiving countries) have yet to be hammered out. This is the purpose of the SRFA-level FSMPs. So far, little emphasis has been placed on initiating the FSMP formulation and implementation exercise for the SRFAs. This process must be accelerated if the SRFAs—which were established as fire suppression organizations—are to function as intended during subsequent ENSOs.

The magnitude of the task involved is enormous, calling for focused attention in the period ahead.

Monitoring (also some other elements of fire management) has two broad components complementing each other: (i) remote level, high technology-based and (ii) local level, manual or low-technology-based. Extreme care is necessary to establish a proper balance between these two aspects, and not to be enamoured solely by one. The 1997-1998 fires and haze showed that overreliance on satellite monitoring and neglect of local surveillance and communication systems can produce seriously adverse results. Further, the experience of the RETA Project with regard to implementing the ORHAP's monitoring component is that it can be relatively easy and quick to formulate, design, and implement.

The monitoring component of the ORHAP has seen relatively rapid progress. A related issue is that in the future, emphasis should shift from the regional level to upgrading the capacity of the national-level weather institutions. In the medium term, particular attention should be paid to reducing the differences in monitoring capacity among the various AMCs. Basic-level communication facilities (e.g., access to ASMC's intranet) should be assured for all member-country weather institutions. Here again commitment is a prime condition.

The magnitude of the task involved is enormous, calling for focused attention in the period ahead

Participation should continue in implementation of the plan, particularly at local levels

Forest Fire and Haze Outlook in the ASEAN Region

Future Forest Fires and Haze

Experience tells us that forest fires are likely as long as there are forests. However, the number and intensity of fires can be reduced through rational and balanced management interventions.

Fire risk modeling in expected future climate change scenarios and other influencing factors indicate that within the next three to four decades, the destructiveness of human-caused and natural wildfires will increase. Due to the multidirectional and multidimensional effects of fire on the different vegetation zones and ecosystems, and the manifold cultural, social, and economic factors involved, suitable fire management strategies will have to be evolved to counter the predicted situations.

Influence of Demographic Changes

Human population growth can make a bad situation worse by putting ever more pressure on available land and other resources. According to the UN's middle estimate among seven fertility scenarios, the human population will rise (from the present six billion) to 9.4 billion by the year 2050, then to 10.8 billion by 2150 before leveling off at the end of the 22nd century. The collective impact of this growth will be overwhelming. The impact, however, cannot be measured simply by population figures. It will be a product of three variables: population size, consumption level, and technology. High consumption increases the impact of a given population; whereas technological developments may either exacerbate (by excessive exploitation) or mitigate it (by improving efficiency). In any case, more people will need more total land. And, possibly, more open fires to clear the land.

The most popular view holds that for several years in the future, population growth and pressure on natural resources will keep the fires and associated haze a live issue.

Influence of Climate Change Convention

The UN Framework Convention on Climate Change (UNFCCC) on land use and land-use changes may indirectly influence forest protection, positively or negatively. If deforestation is effectively controlled, reduced impact logging is seriously practiced, and forest fire management measures are intensified, forest fires and haze will, in all likelihood, be reduced in number and intensity. In this regard, it is necessary that forest and forest fire managers follow the evolution of climate change policy to assess its implications on fires and haze.

People's Participation

In strategic planning, a participatory process envisages that consultations should take place at all stages, so that the plan will be owned by all those involved, which in turn will help in the effective achievement of objectives. Participation should continue in implementation of the plan, particularly at local levels. This will bring dynamism into the planning process, and will ensure that planning will be made more effective and responsive to real needs.

Participation is a process of social action and social change. Millions of people living in rural areas, in and around forests, depend on forests for their livelihood. Often, their aspirations for a more decent, secure, and equitable way of life are tied up with forestry development. Organized and informed participation of these people can help all parties involved to find solutions to their problems.

Local membership organizations such as cooperatives, tenant leagues, and women's groups constitute a third sector, balanced between the public and private sector, to ensure that the group's problem is appropriately considered in the development planning process (Esman and Uphoff 1982). Grassroots groups will have to interlock with governments, private companies, and NGOs as a strategic alliance.

Participation and intensive consultation strengthen the planning process by encouraging transparency, improving access to information and ideas, helping in conflict resolution and feasible choices, and enabling general acceptance of decisions.

People's participation in formulating and implementing FSMPs will be a feasible and useful approach. If smallholders, community groups, and local NGOs are also parties to the interagency agreements that define the roles and responsibilities of those undertaking the FSMPs, it will provide a forum to sort out conflicts. But, in most cases, in forestry, participation is peripheral and symbolic, more to legitimize the process than to produce results.

Nonmaterial motivation, through allowing participation in discussions, though laudable, is not a practical system; improvement in social conditions and living standards is the basic urge that drives people to participate. Under these circumstances, participation should involve productive engagement.

The Larger Context

ASEAN is a rich region in terms of natural flora and fauna, timber, and NWFPs. In its larger context, fire and haze management in AMCs is also an issue of environmental security covering resource development, biodiversity conservation, sustainable management of forests, food security, employment, related institutions, and infrastructure. The need for a holistic approach to address forest fires and haze is, therefore, evident.

Strengthening Regional Collaboration

The way ahead to achieve the ORHAP's objectives should be by unflagging efforts to continuously strengthen regional collaboration and cooperation. This can be achieved through joint activities, fine-tuning of policies, adopting common standards and approaches, establishing legal instruments on important aspects of regional collaboration, effectively institutionalizing management of forest fires and haze, formulating a long-term framework and perspective plan for fire management, and ensuring proper balance of the program structure. It is also necessary to provide increasing clarity to the functions of the different ASEAN bodies concerned with fire and haze management.

> The way ahead to achieve the ORHAP's objectives should be by unflagging efforts to continuously strengthen regional collaboration and cooperation

Joint Activities

Joint activities suitable for the different contexts and circumstances are an important means of strengthening the regional approach. Policy studies, research and development, specialized training, remote sensing and satellite-based monitoring, and SRFAs are some of the activities on which cooperation has been initiated. This cooperation needs to be further strengthened. As and when conditions become more conducive, and if economy and efficiency warrant it, more and more activities relating to fire management can be brought under the regional preview.

Continuation and Completion of Ongoing Activities

Several activities have been initiated by the ORHAP under the auspices of ADB's RETA Project. Some activities have been started and are ongoing, some are in a nascent stage, and others are still in the form of a plan awaiting approval for funding. Some activities are of considerable magnitude, some are complex in nature; some are of short-term, and others are of medium-term implication.

An important task ahead is to carry these forward, enhance their functioning or complete them as necessary in order to realize the goals. There are various activities to be seen through. These include completing the network of FSMPs, linking village units all the way up to the subregional (SRFA) level; increasing and improving the monitoring capacity of AMSC and establishing an effective monitoring system network; pursuing and completing the work on policy changes involving introduction of market-based instruments, a system of responsible land clearance bonds, mechanical land clearing, and model codes of practice; starting training programs on firefighting, fire management and monitoring; and establishing the Regional Research and Training Center for Land and Forest Fire Management.

There is a clear need for proper documentation of fires across the ASEAN region

Some of the areas where focused attention is required in the short term would include working toward common standards and approaches (e.g., haze pollution indexes, fire monitoring standards, and capability); and establishment of an ASEAN Haze Fund.

There is a clear need for proper documentation of fires across the ASEAN region. While general occurrence of fire and fire-generated smoke at regional level is known, there is still a lack of information on seasonal and spatial distribution of fires in the various land-use systems and wildlands. Fire monitoring on a regional scale is not necessarily aimed at firefighting operations. They must be arranged within the individual countries. Regional fire activity monitoring should include the evaluation of archives with historic satellite data in order to identify possible changes of fire regimes.

Another issue, relating to implementation of the monitoring program, is that in the future, the emphasis should shift from the regional level to upgrading the capacity of national-level meteorological institutions. In the medium term, particular attention should be paid to reducing the differences in monitoring capacity among the various AMCs. Basic-level communication facilities (e.g., access to ASMC's intranet) should be assured for all AMC meteorological institutions.

Consultation and New Activities

A means of strengthening regional collaboration is through regular consultation among the AMCs to review the implementation of the ORHAP and to assess the need for program modification, including new activities. Some ideas have already come up.

- A proposal is being considered regarding publication and distribution of an ASEAN *Forest Fire Bulletin* on a regular basis to disseminate information on occurrence and extent of fires, estimated impacts, research results, technological breakthroughs, experience with application of specific technologies, information on weather patterns, policy developments, etc., from within and outside ASEAN.
- Considering the commonality of forest fire-related issues and problems, apart from cost-effectiveness, AMCs can gain considerable advantages by establishing pan-ASEAN fire centers or strengthening existing ones, while sharing facilities, knowledge and experience in aspects such as fire science and technology, and fire management planning. These can be linked to the Regional Research and Training Center for Land and Forest Fire Management.
- The ORHAP at present does not include activities relating to the effects of forest

fires and haze on public health, and measures to mitigate such impacts. The NHAP (draft) of Malaysia has incorporated public health warning and mitigation measures in its activities. It would be appropriate to acknowledge the relevance of it, through incorporating a corresponding activity in the ORHAP, even if on a token scale.

- There are no separate entities dealing with fire weather, nor are there dedicated satellites for fire monitoring. A recommendation has been made at the WMO Workshop (2-5 June 1998) held in Singapore to develop dedicated satellites for fire monitoring that will have better spatial and temporal resolution than existing satellites. It was also suggested that the next generation fire satellites should provide for better characterization of fire temperature and resulting gaseous and particulate emission measurements. The latter information can be used to initialize ATMs that can forecast the development and dispersal of pollutants in the region. This idea needs to be pursued.

Fine-Tuning of Policies

There are no separate forest fire policies in the AMCs. Fire-related policies are included as clauses or provisions in other related policies; e.g., in a forest policy, environmental policy, or land development policy. Separate regulations corresponding to these policy clauses are often issued. These lead to inconsistencies and even conflicts as far as forest fire- and haze-related policies are concerned. There is need to fine-tune fire-related policy provisions by removing inconsistencies and providing for appropriate focus. Better still, a separate policy statement on forest fires and haze can be formulated—following accepted procedures involving policy articulation and formulation.

Promoting policy changes relating to the use of fires that cause atmospheric pollution is difficult. This is a medium-term task that is being undertaken by some countries with bilateral support from international donors.

ASEAN Regional Framework Policy

An ASEAN regional framework policy on forest fires and associated haze can serve as a model for the AMCs to formulate their own policies (or modify the existing policy provisions) to suit their needs.

> An ASEAN regional framework policy on forest fires and associated haze can serve as a model for the AMCs to formulate their own policies

No single policy formula can cover the wide range of ecological, socioeconomic, and cultural conditions found in AMCs. But there are certain broad principles common to all situations, including:

- the need for formulation of policies specifically addressing forest fires and haze autonomously or as an integral component of land-use policies;
- flexibility in policy implementation, and the capability to review and revise fire-related policies;
- clear and measurable policy objectives and implementation strategies; and
- involvement of all stakeholders in policy development, especially through devolved or community participatory approaches.

Formulating and promulgating a policy does not necessarily guarantee that it will be followed. Policy implementation needs to be ensured through strict enforcement.

Common Standards and Approaches

For joint efforts, as envisaged in the ORHAP, to succeed, common standards and common approaches are required. The need for harmonization of haze pollution indexes, standardization of the FDRS and hot spot algorithms, a common curriculum for fire management training, standard terms and definitions, and a common/harmonized system of weights and measures exemplify the importance of common standards.

Similarly, there are several aspects (e.g., policy and regulations) where common approaches will help to strengthen regional cooperation. Methods of land clearance and preparation, reduced-impact forest harvesting, use of market-based instruments, and land clearance bonds, and institutional arrangements are cases where common approaches and guidelines can be applied.

For international agreements to be drawn up covering various aspects of the ORHAP, it is necessary to have an enabling legal instrument

Before common adoption by all AMCs, the merits and demerits of the standards and approaches should be discussed in specially organized workshops to clarify issues and implications and to make necessary modifications. Training for staff, including demonstration of the use of common standards and approaches, should be provided.

Legal System for Regional Cooperation

A legal system for the ORHAP will involve various levels and types. ASEAN's legal system may be sufficient to cover some of the ORHAP's general aspects (e.g., personnel, financial control). In the case of fire and haze management involving more than one country, specific agreements are needed, enabled by a superior instrument such as a protocol or a mother agreement.

The different levels in the legal system of the ORHAP will roughly be as follows: regional-level convention or a mother agreement; specific protocol(s) (e.g., on transboundary haze pollution control); agreements relating to a specific situation (e.g., an agreement for sharing weather information); and SOPs for actions falling within the purview of specific agreements (such as cross-border transfers of firefighting equipment).

Instrument for Transboundary Haze Pollution Control

For international agreements to be drawn up covering various aspects of the ORHAP, it is necessary to have an enabling legal instrument. Sustained implementation of the ORHAP would significantly be helped by a mother agreement or a comparable legal instrument that embodies the various agreements at the bilateral, subregional, and regional levels. The ASEAN Regional Agreement on Transboundary Haze Pollution Control initiative needs to be pursued as a priority.

Other Legal Aspects

Some of the other important activities that have a legal dimension include the following:

- ASEAN Haze Fund to support the ORHAP, and its legal status;
- partnership agreements with donors for specified support; and
- the ORHAP's claim to be qualified for coverage under the Clean Development Mechanism (CDM).

CDM and Forest Fire Management

The eligibility of land-use activities for the CDM is a gray area. Forest fire management, rehabilitation of fire-affected areas, and haze pollution control are, at present, not qualified for CDM support. The interpretation is that only fossil-based emission reduction activities are allowed.

Institutionalizing Forest Fire and Haze Management

The sustainability of human-made systems (such as forest fire and haze management) depends on how effectively it has been institutionalized with appropriate mission, structure, and controls for continued and efficient functioning. The institutional framework has to be sound and capable of systematic enhancement.

ADB is finalizing an advisory and operational technical assistance for institutionalization of forest fire and haze management in Indonesia.

The objectives of the technical assistance are to assist Indonesian institutions to develop and design appropriate policies, legislation, guidelines, structures, and procedures to institutionalize prevention, mitigation, control, and monitoring of land and forest fires and associated haze pollution. It will also determine the need for capacity building at various levels of government and related NGOs; and develop a nationwide extension and education program. This would require identification of a single lead institution that would have the authority and be accountable for all operations dealing with land and forest fire management. The lead institution would establish legally binding coordination and collaboration mechanisms and relationships with other institutions in the country for effective management. The process can, as appropriate, be extended to other AMCs.

A Perspective Framework for the ORHAP

The emphasis of the ORHAP is on implementation and action. As a rolling six-year plan, its horizon is short. While this has merits from the short-term operational point of view, its lack of a long-term perspective has serious disadvantages, particularly affecting the consistency of approach and direction. This will cause the planners' bias to be reflected in the add-on plans—potentially leading to unsteady or lack of progress.

On the other hand a long-term perspective plan (of which the ORHAP will be a part) has the advantage that it can better rationalize the program structure and balance, to achieve the goals in the shortest possible time. As the perspective plan, by definition, will be closely linked with other related sectors, it also helps to obtain a holistic understanding of the ecological and human aspects of forest fires and haze. This is an aspect to be considered in the future and acted upon.

Program Status for Institutional Strengthening

In spite of the ORHAP principle that ASEAN's fire and haze problem cannot be fixed but should be managed, there is the danger that it may still concentrate on technical aspects. However, the most important impediment in fire and haze management has been institutional weaknesses. The three programs of the ORHAP (prevention, mitigation and monitoring) are technical programs; it may be worthwhile to add institutions (or institutional strengthening) as another.

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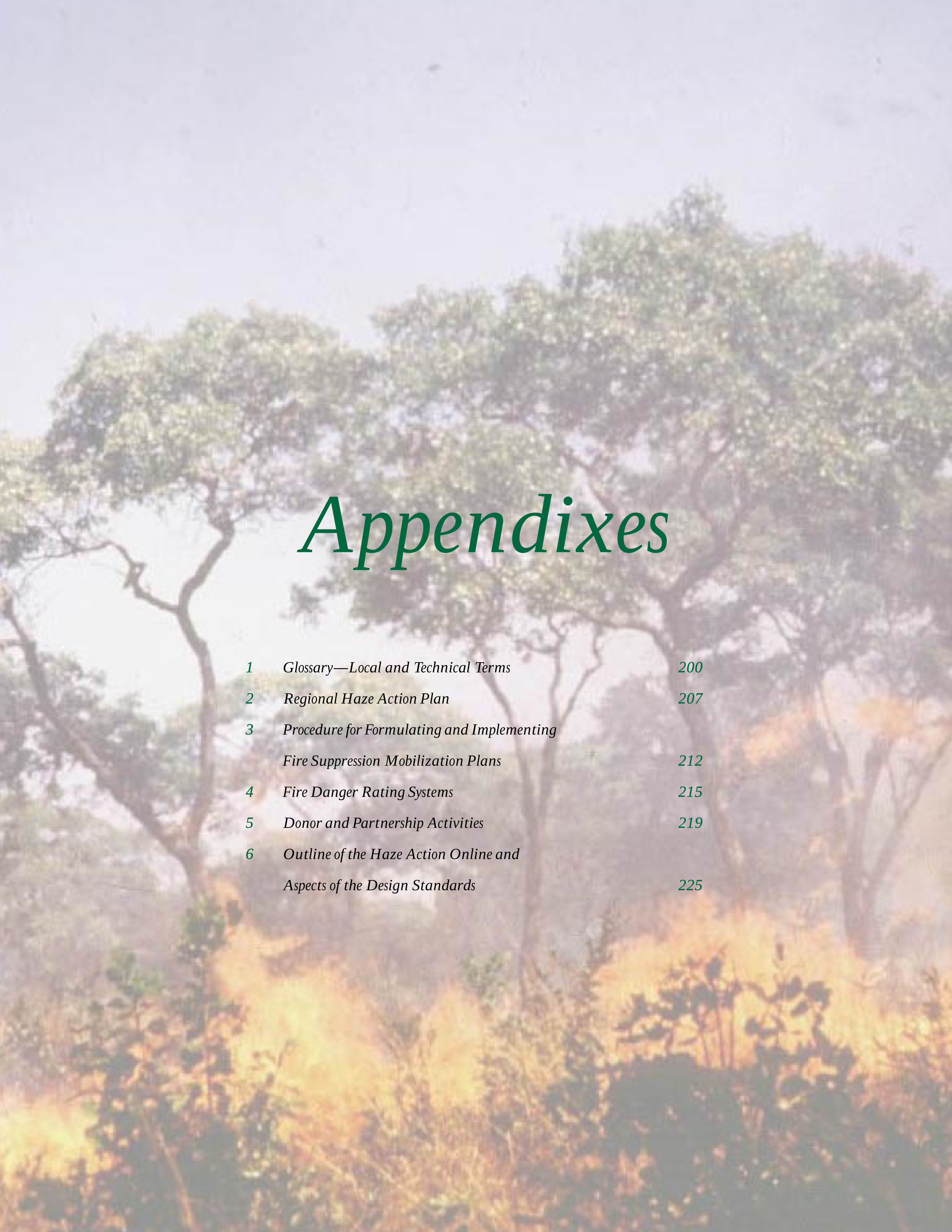
Upgrading of CSU

The ORHAP's success in the years to come will depend on CSU's dynamism. It must be provided with adequate resources and skills/ expertise, in view of its singularly vital role.

Conclusion

The ORHAP has been designed as a people-oriented, public-interest-propelled system that aims to defend the human environment, and particularly to prevent transboundary haze pollution. Through its mission to manage forest fires and associated haze, the ORHAP can and should serve as a stabilizing force to support land- and forest-based development in the region. The laudable commitment of ASEAN in this regard needs to be kept undiminished. Complacency should be avoided if this commitment is not to be blunted.



Appendixes

APPENDIX 1

Glossary—Local and Technical Terms

Aerial fuels	The standing and supported forest combustibles not in direct contact with the ground and consisting mainly of foliage, twigs, branches, stems, bark, lianas, and other vines. In general, they easily dry out and may carry surface fires into the canopy.
Afforestation	Establishment of a forest by artificial means on an area from which forest vegetation has always or for a long time been absent.
Agroforestry	Land use system in which woody perennials are grown and/or used on the same land as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence.
Alang-alang	*Imperata* grass (in Indonesia and Malaysia).
Atmospheric mixing depth	The vertical depth of atmospheric mixing (usually away from the surface) determined mainly by the atmospheric temperature profile.
Backfire	A fire set along the inner edge of a control line to consume the fuel in the path of a forest fire and/or change the direction of force of the fire's convection column. Note: A small-scale fire with closer control, in order to consume patches of unburned fuel and aid control-line construction, is distinguished as "burning out," "firing out," or a "clean burning."
Barangay	Village, organized community (in the Philippines).
Biodiversity	The variety and abundance of plants, animals, and microorganisms as well as the ecosystem and ecological processes to which they belong. This includes diversity within species, between species, and of ecosystems.
Broadcast burning	Allowing a prescribed fire to burn over a designated area within well-defined boundaries for reduction of fuel hazard, as a silvicultural treatment, or both.
Center firing	A method of broadcast burning in which fires are set in the center of the area to create a strong indraft; additional fires are then set progressively nearer the outer control lines as indraft builds up so as to draw them in toward the center.
Closed forest	Forest with stand density greater than 20 percent and the crowns approaching general contact with one another.
Controlled burns	Fires started purposely to achieve specific objectives.
Control a fire	To complete a control line around a fire, any spot fires therefrom, and any interior islands to be saved, and cool down all hot spots that are immediate threats to the control line,

	until the line can reasonably be expected to hold under foreseeable conditions.
Convection	Vertical exchange of air parcels, sometimes resulting in cloud formation.
Counterfire	Fire set between main fire and backfire to hasten spread of backfire. Also called draft fire. The act of setting counterfires is sometimes called "front firing" or "strip firing."
Crown fire	A fire that advances from top to top of trees or shrubs more or less independently of the surface fire.
Deforestation	To remove, kill, or destroy all or most of the trees of a forest so that reproduction is impossible except by artificial means.
Drip torch	A hand-held apparatus for igniting prescribed fires and backfires by dripping flaming fuel on the materials to be burned. The device consists of a fuel fount, burner arm, and igniter. The fuel used is generally diesel or stove oil with gasoline added.
Early burning	Prescribed burning early in the dry season before grass, tree leaves, and undergrowth are completely dry, or before the leaves are shed; as an insurance against more severe fire damage later on.
Ecosystem	An ecological system, the basic functional unit in ecology, a dynamic complex of plant, animal, and microorganism communities and their associated nonliving environment interacting as an ecological unit.
El Niño Southern Oscillation (ENSO)	A fluctuation in interpolitical pressure, wind, sea surface temperature, and rainfall and an exchange of air between the southeast Pacific subtropical high and the Indonesian equatorial low.
Environmental services:	Includes the maintenance of biodiversity, protection of soil and water resources, moderation of climate, influencing of rainfall, sequestering of carbon dioxide, providing habitat for wildlife, and maintenance of the earth's natural balance.
Fine fuel	The component of the biomass that, when burning, contributes to the flame front. (Forest fires have a flame height and flame depth that are approximately equal. The flame front moves through the fuel matrix with a speed of propagation that depends on the dryness of the fine fuel, the wind speed, and the quantity of fine fuel. Thick fuels burn after the passage of the flame front. Fine fuels are usually defined in terms of the thickness of the thinnest dimension. A leaf that may be 2.5 mm thick, 100 mm long, and 40 mm wide would be classified as a 2.5 mm fuel. Fine fuels usually range between 0 t per ha (for freshly burned country) to 4-10 t per ha for

	grasslands, 5-25 t per ha for dry forests, and up to 45 t per ha for wet forests.
Firebreak	Any natural or constructed discontinuity in a fuelbed utilized to segregate, stop, and control the spread of fire; or to provide a control line from which to suppress a fire; characterized by complete lack of combustibles down to mineral soil (as distinguished from fuelbreak).
Fire climax	Vegetational climax maintained by occurrence of fires at regular intervals (also known as pyric climax).
Fire danger rating	A component of a fire management system that integrates the effects of selected fire danger factors into one or more qualitative or numerical indexes of current protection needs.
Fire hazard	A fuel complex, defined by volume, type, condition, arrangement, and location, that determines the degree both of ease of ignition and of fire suppression difficulty.
Fire intelligence	All infrastructures, communication, base data, and other hard- and software that provide the inputs to an information and decision support system in fire management.
Fire intensity	The quantity of heat liberated in the flame front for every meter of fire width. It is calculated by the Byram Line Intensity Index (I megawatts per meter where $I = HWR$. H is the calorific value of the fuel and can be taken as 17 megajoules per kilogram, W is the fuel concentration in kilograms per square meter, R is the rate of spread in meters per second).
Fire retardant	Any substance except plain water that by chemical or physical action reduces the flammability of fuels or slows their rate of combustion, e.g., a liquid or slurry applied aerially or from the ground during a fire suppression operation.
Fire risk	Measure of the likelihood that a wildfire will be ignited naturally or through human action.
Flame depth	The distance from the leading edge of the flame front to the point at the back of the flame front just outside the flame mantle.
Forestry	The scientific management of forests and trees for the continuous production of goods and services. Forestry has evolved to include, in many countries, groups of scattered trees, agroforestry plots, urban tree planting, small woodlots, and also wildlands that do not support tree populations. In fact, forestry has evolved from tree management to the management of complex ecosystems, and their utilization.
Forest influences	All effects upon water supply, soil, climate, and health resulting from the presence of forests.

Forest residue	The accumulation in the forest of living or dead, mostly woody, material that is added to and rearranged by human activities such as forest harvest, cultural operations, and land clearing.
Forest type	A descriptive term used to group stands of similar character with regard to composition and development due to certain ecological factors by which they may be differentiated from other groups of stands.
Fuel	All combustible organic material in forests and other vegetation types, including agricultural residue.
Fuelbreak	Generally wide (20-30 m) strips of land on which either less flammable native vegetation is maintained and integrated into fire management planning, or vegetation has been permanently modified so that fires burning into them can be more readily controlled as distinguished from firebreak. Some fuelbreaks contain narrow firebreaks that may be roads or narrower hand-constructed lines. During fires, they can quickly be widened either with hand tools or by firing out. Fuelbreaks have the advantages of preventing erosion, offering a safe place for firefighters to work, low maintenance, and a pleasing appearance.
Genetic resources	Actual or potential characteristics of plants and animals that are transmitted genetically and may include disease resistance, rapid growth, yield or quality factor, or the presence or absence of a chemical. These characteristics, i.e., genetic diversity, reside in the germ plasm of different cultivars, races, and varieties of a species.
Greenhouse warming	A possible increase in global temperatures associated with changes in atmospheric trace gases.
Ground fire	A fire burning in organic terrain, e.g., dried tropical swamps and peat layers.
Hadley circulation	A north-south circulation of air in low latitudes, with air rising in the intertropical convergence zone and sinking in the adjacent subtropical zone.
Intertropical convergence zone	The zone of persistent convergence of trade wind airflow in the lower troposphere in low latitudes.
Kabupaten	Regency (subdivision of a province, in Indonesia).
Kecamatan	Subregency (district, in Indonesia).
Ladder fuels	Fuels that provide vertical continuity between stratums. Fire is able to carry from surface fuels into the crowns of trees or shrubs with relative ease and help assure initiation and continuation of crown fires.

Land-use capability	The production capacity or usefulness of soil based upon its quality with reference to nutrient status, climatic factors, drainage, degree of slope, etc.
Mass fire	A fire resulting from many simultaneous ignitions. These fires generate high levels of energy output.
Mesoscale	A spatial scale for weather systems with typical horizontal dimensions of ~10-1,000 km.
Nonwood forest products	Consist of goods of biological origin other than wood, as well as services, derived from forests and allied land uses.
Pioneer species	A plant species capable of establishing itself in a bare or barren area and initiating an ecological cycle.
Preattack planning	Fire planning within designated blocks of land, covering the following items: locations of firelines, base camps, water sources, helispots, transportation systems, probable routes of travel, constraints of travel on various type of attack units, determining of construction of particular firelines, the probable rate of line construction, topographic constraints on line construction, etc.
Prescribed burning	The controlled application of fire to wildland fuels in either natural or modified state, under specified environmental conditions that allow the fire to be confined to a predetermined area and at the same time to produce the intensity of heat and rate of spread required to attain planned resource management objectives.
Prescribed fire	A fire burning within prescription. The fire may result from either planned or unplanned ignitions.
Presuppression planning	All measures of fire intelligence and preparedness for fire suppression actions.
Primary forest	Unlogged forest.
Productivity	The relationship between the output of goods and services and the input of resources (factors of production) used to produce them.
Production forest	Forest designated for the sustained production of timber and other forest products, often with protection and/or nature conservation as recognized secondary objectives, chosen because of their potential to provide a yield of high-quality timber in perpetuity. This category may also include degraded areas appropriate for reforestation. In general usage, the term covers natural forests, forest plantations, woodlots, agroforestry plots, homestead forests, etc.
Protection forest	An area wholly or partly covered with woody growth, managed primarily for its beneficial effects on water, climate, or soil

	rather than for forest products or services, and involving fragile lands, critical soils, catchment areas, steep slopes, and land at high altitudes. Controlled sustainable extraction of nonwood forest products is often allowed in protection forests.
Quasi-biennial oscillation	An (approximately) two yearly reversal in wind direction that occurs in a number of parts of the earth's atmosphere.
Radiosonde	A balloon-borne device allowing upper air measurements of temperature, humidity, pressure and/or height, wind speed, and direction.
Rate of speed	The speed that a fire front travels ranges up to 25 kilometers per hour (km/h) for grasslands to about 12 km/h for forests. Most fires travel at much slower speeds and typical speeds are usually less than 1 km/h for grasslands and 0.5 km/h for forests.
Reforestation	Restocking and/or replanting of an area that has been cleared of its forests earlier.
Rotation	The period of years required to establish and grow forest crops to a specified condition of maturity.
Seasonal forest	A closed deciduous forest, or an open forest with continuous grass cover, distinguished from other tropical forests by distinct seasonality and low rainfall. Includes closed forests made up of deciduous hardwoods that shed their leaves during the dry season and woody and/or tree savannahs.
Secondary forest	A forest subjected to a light cycle of shifting cultivation or to various intensities of logging but still containing indigenous trees or shrubs.
Shaded fuelbreak	Fuelbreaks built in forest areas where the trees on the break are thinned and pruned to reduce the fire potential, yet retain enough crown canopy to make it possible to control surface fires more easily.
Shifting cultivation	Farming system, carried out in the forest areas, in which the land is periodically cleared, farmed, and then returned to fallow.
Slash-and-burn agriculture	Farming, (usually small-scale), in which plots are prepared by cutting and burning off vegetative cover.
Smoke management	The application of knowledge of fire behavior and meteorological processes to minimize air quality degradation during prescribed fires.
Stand	An aggregation of trees or other growth occupying a specific area and sufficiently uniform in composition, age arrangement, and condition so as to be distinguishable from the forests or other growth on adjoining areas.
Succession	The gradual supplanting of one community of plants by another. Inherent in the definition are three considerations:

	(i) succession is orderly, directional, and therefore predictable; (ii) succession can occur when the community itself modifies the physical environment so that other populations can be established; and (iii) succession culminates in a relative stable community.
Surface fire	Fire that burns only surface litter, other loose debris of the forest floor, and small vegetation.
Sustainable forest management	Forest management for multiple uses (including biodiversity preservation, timber harvesting, extraction of nonwood products, soil and water conservation, tourism, recreation, and enjoyment of natural amenities) based on an ecosystem concept that allows utilization of forests without undermining their use by present and future generations. Different systems of management would be required for each category of forests depending on the intended output.
Sustained yield	As applied to policy, method, or plan of forest management, implies continuous production with the aim of achieving at the earliest time an approximate balance between net growth and harvest, either by annual or somewhat longer periods.
Sustainable yield:	The measure of material that a resource can yield annually or periodically in perpetuity.
Swidden	See *"slash-and-burn agriculture."*
Trade wind	Low-level tropical easterly winds representing the lower component of the Hadley circulation.
Troposphere	The lowest part of the atmosphere, where temperatures generally decrease away from the surface.
Vegetation fires	Fires in all vegetation types including forests, grasslands, scrublands, and agricultural lands.
Walker circulation	A thermally driven east-west cellular circulation extending across the Pacific Ocean, from Indonesia to close to the Peruvian coast.
Wildfire	Any fire occurring on wildland except under prescription.

APPENDIX 2

Regional Haze Action Plan

(Approved in December 1997)

A. Introduction

1. Smoke haze affected Southeast Asian countries during the dry seasons in 1991, 1994, and 1997. From July to October 1997, members of the Association of Southeast Asian Nations (ASEAN), in particular Brunei Darussalam, Indonesia, Malaysia, and Singapore, were badly affected by smoke haze caused by land and forest fires. The Philippines and Thailand were affected to a lesser degree. The severity and extent of the smoke haze pollution were unprecedented, affecting millions of people across the region.
2. The economic loss suffered by countries during this environmental disaster was enormous and has yet to be fully determined. Several economic sectors, including air, water and land transport, shipping, construction, tourism, forestry, and agriculture, were severely affected. The haze pollution also resulted in a considerable health impact on the people of the countries affected; the long-term health effects have yet to be determined.
3. In June 1995, ASEAN Environment Ministers agreed on an ASEAN Cooperation Plan on Transboundary Pollution. The Cooperation Plan contains broad policies and strategies to deal with transboundary pollution. In light of the latest haze experience, the ASEAN Environment Ministers agreed on a Regional Haze Action Plan (Action Plan), which sets out cooperative measures needed among ASEAN member countries (AMCs) to address the problem of smoke haze arising from land and forest fires in the region.

B. Objectives

4. The primary objectives of the Action Plan are to:
   (i) prevent land and forest fires through better management policies and enforcement;
   (ii) establish operational mechanisms to monitor land and forest fires; and
   (iii) strengthen regional land and forest firefighting capability and other mitigating measures.

C. Preventive Measures

5. AMCs recognize the need to strengthen national policies and strategies to prevent and mitigate land and forest fires. While some AMCs have already developed their national policies and strategies, others are in the process of advancing them based on their own development needs, priorities, and concerns.
6. AMCs will develop national plans to encapsulate their policies and strategies to prevent and mitigate land and forest fires. The plans should contain the following common elements:
   (i) policies to curb activities that may lead to land and forest fires and control emissions from mobile and stationary sources, including the prohibition of open burning and the strict control of slash-and-burn practices during the dry period;

(ii) strategies to curb activities that may lead to land and forest fires and control emissions from mobile and stationary sources, including the following:
   (a) formulation of air quality management legislation to prohibit open burning;
   (b) strict enforcement of laws and legislation;
   (c) implementation of air quality monitoring and reporting regimes, and setting up surveillance on local sources of emissions, both mobile and stationary;
   (d) establishment of a national task force and/or committee to develop strategies and response plans to deal with fires and smoke haze; and
   (e) utilization of information technology to provide haze-related information to relevant agencies to prevent and control spread of fire, and to enhance public awareness on the haze situation;

(iii) guidelines and support services to discourage activities that can lead to land and forest fires;

(iv) operating procedures for the early mobilization of resources to prevent the spread of fires; and

(v) development of markets for the economic recovery and utilization of biomass (e.g., briquette) and appropriate methods for the disposal of agricultural waste.

7. These national plans were completed by March 1998. An ASEAN workshop was conducted in April 1998 to facilitate cross-comparison of the National Plans and exchange of information, including the exchange of legal experience in managing land and forest fires.

C. Regional Monitoring Mechanisms

8. The Action Plan will strengthen the region's early warning and monitoring system to provide an alert of the first outbreak of land and forest fires, an assessment of meteorological conditions, a prediction of the spread of smoke haze, a systematic tracking of the control and spread of fires and haze, and the necessary data to support enforcement action. As part of this effort, the ASEAN Specialized Meteorological Centre (ASMC) will be further streamlined and strengthened. ASMC will serve as a regional information center for compiling, analyzing, and disseminating information derived from satellite imagery and meteorological data necessary to detect and monitor land and forest fires and the occurrence of haze.

9. ASMC will operate by March 1998 an intranet among the relevant ASEAN meteorological service and environmental agencies to improve communications and enhance the effectiveness of existing early warning and monitoring systems. Information that will be made available on the intranet will include the following: satellite imagery, wind charts, visibility information, air quality information, and other meteorological and environmental information useful for haze monitoring.

10. In early 1998, the ASMC will conduct a regional workshop involving meteorological experts from within and outside ASEAN to discuss climate prediction for the region in 1998-1999. In the longer term, ASMC will further enhance the intranet system by including the following: seasonal climate prediction, haze dispersion modeling products, and a forest fire danger rating index.

D. Firefighting Capability

11. National and regional land and forest firefighting capability will be strengthened through the following measures:

   (i) Complete by March 1998 the ongoing preparation of the inventory of land and forest firefighting capability of each country (agencies, human resources, equipment, available land and forest fire hazard maps, and other resources) and identify resources that can be made available for regional firefighting efforts.

   (ii) Formulate by March 1998 a program to strengthen the firefighting capability of individual countries and the region, and compile a list of equipment and technical expertise that is needed at the regional level to tackle land and forest fires.

   (iii) Identify by March 1998 the sources of technical assistance for within and outside ASEAN and, if required, formalize an assistance program with each donor country. Technical assistance may include forest firefighting equipment, aircraft such as water bombers, and high-tech equipment and experts for command post operations.

   (iv) Establish by June 1998 an operating procedure to activate the deployment of the firefighting resources in each country for regional firefighting operations.

   (v) Establish by June 1998 a mechanism in each country to provide, in the event of an outbreak of land and forest fires, regular updates to the Haze Technical Task Force (HTTF) on progress made in efforts to fight the fires. The updates would include the number of hot spots and their locations, analysis of fire types, problems encountered, adequacy of deployed resources, and effectiveness of enforcement and ground operations.

E. Detailed Scope of Technical Assistance

12. ADB's assistance was sought to provide consultancy services in support of the Action Plan. The scope of the technical assistance is as follows.

13. The following short-term measures will be completed within three months of commencement:

   (i) Compile and analyze ongoing national and regional fire and haze prevention programs with a view to sharing relevant experience, improving coordination, and avoiding duplication of effort. Based on the findings, make recommendations how national and regional fire and haze prevention measures can be improved in the short and medium term.

   (ii) Inventory existing fire management and suppression capabilities in the affected AMCs, and develop technical assistance programs and partnerships within and beyond the region to strengthen these capabilities. (Several international and bilateral organizations had expressed interest during the 1997 fires and haze to offer assistance in this area).

   (iii) Strengthen the capacity of the ASEAN Secretariat, ASEAN Senior Officials on Environment (ASOEN), the working group on transboundary pollution, and the Haze Technical Task Force (HTTF), in the effective delivery of their functions in fire and haze prevention and mitigation.

(iv) Improve information management and dissemination in the ASEAN Secretariat related to fire and haze prevention and mitigation, including the sharing of knowledge and experience, dissemination, coordination, and monitoring of national, regional, and international initiatives with institutions concerned in the region. This includes the establishment and maintenance of an intranet between institutions in the region and a public information service through the ASEAN worldwide web home page.

(v) Compile initial results of ongoing studies on the impact of transboundary atmospheric haze pollution on affected ASEAN countries, collect additional information where required, and compile a comprehensive impact assessment covering all economic sectors concerned as well as social (including health related), and environmental impacts. Detailed assessment would be carried out over the medium term.

(vi) Compile and analyze existing policies and legislation in countries concerned regarding sustainable land-use practices with and without the use of fire for land clearing, and recommend appropriate changes.

(vii) Compile experience within and beyond the region with fire prevention and control, including land-clearing fires and wildfires, mitigation strategies, etc., and document relevant lessons learned.

(viii) Based on the outcome of the above items (i-vii), provide assistance to the HTTF in finalization of the Action Plan, identification of institutions responsible for various implementation actions, including institutionalized monitoring and review of policies, strategies, legislation, guidelines, early warning pertaining to fire danger and potential pollution hazard, personnel mobilization for prevention of spread of fires, and other aspects of the Action Plan; and providing regular updates to members concerned on the progress of actions taken or pending and need for follow-up actions.

14. The following medium-term measures will be completed within 12 months (several of these measures will be initiated concurrently with the short-term measures):

(i) Strengthen the capacity of ASMC in Singapore to compile and analyze available ground, atmospheric, and remotely sensed data on land and forest fires, haze, related climate and weather patterns, and other relevant environmental parameters, in collaboration with national meteorological agencies, and to disseminate the information, including early detection and warning through established institutional arrangements with national agencies concerned. The collaboration with national agencies is particularly necessary to compile data from a larger geographical area.

(ii) Compile available information within and beyond the region regarding the use and marketing of biomass and logging residue products, such as briquettes, mulch, and compost. This includes a study of market-based instruments to promote such products and thereby stimulate mechanical land-clearing methods.

(iii) Taking due account of various national and regional initiatives, evaluate the existing and proposed systems pertaining to fire danger rating, and fire detection and monitoring: based on these initiatives and the information thus generated, promote the development of land and forest fire hazard maps, and standardized national and regional fire danger rating and fire detection and monitoring systems.

(iv) Develop regional training programs, exchange visits, secondments, partnerships, joint training exercises, in fire management, remote sensing of fires and haze, the application of geographic information systems (GIS), and other priority subjects.

(v) Compile the results of ongoing studies on the impact of transboundary atmospheric pollution on affected AMCs, collect additional information where required, and compile a comprehensive impact assessment covering all economic sectors concerned as well as social (including health related) and environmental impacts. The assessment would include the results from the national impact assessment in Indonesia financed under the complementary advisory technical assistance. It would compare the impact of the 1997 fires and haze with that of previous episodes, and would provide scenarios of possible future impact according to the level of concerted preventive action taken by affected AMCs.

(vi) Develop technical assistance programs and partnerships to undertake scientific studies to improve the monitoring and prediction of transboundary atmospheric pollution, including analysis of the chemistry of emissions, climate, and meteorological patterns affecting pollution formation and dispersal. Such programs would likely involve ASMC, national institutions in AMCs, and partner institutions within and beyond the region, including the World Meteorological Organization and interested bilateral organizations. This would be based on an inventory and analysis of ongoing and planned scientific studies related to forest fires and haze. The project would financially support selected studies to improve the knowledge of haze formation and distribution. One such study could gather information on the chemistry of emissions of land-use fires, to support the haze transport modeling being undertaken by ASMC.

15. Based on the outcome of the above items (i-vi), and in support of and complementary to the earlier developed Action Plan, develop a comprehensive time-bound plan for prevention, monitoring, mitigation, and institutional strengthening, identifying required investments, both at the national and at the regional levels.

16. HTTF will meet monthly to review the progress of implementation of the Action Plan. The ASEAN Environment Ministers will meet regularly to provide guidance on implementation of the Action Plan.

APPENDIX 3

Procedure for Formulating and Implementing Fire Suppression Mobilization Plans

Fourteen Steps for Implementing FSMPs

1. The first step in the exercise is formulation of the initial FSMP document. This requires dispatching a team of fire management specialists with expertise in FSMP drafting to the geographic area to which the FSMP relates. The FSMP drafting team must at the minimum meet with all agencies, organizations, and groups that might cooperate in fire suppression activities in the area. These are likely to comprise local representation of government agencies, nongovernment organizations (NGOs), civic organizations, religious groups, and virtually anyone wishing to cooperate in community-based fire suppression activities.
2. Agreement in principle must at this stage be achieved by all parties that have agreed to cooperate in implementing the FSMP. Without their later support, fire suppression activities will most certainly be compromised. During this step, FSMP formulation comprises the writing out of all resources (personnel, fire suppression tools, communications equipment) available for mobilization in the geographic area to which the particular FSMP relates. The model FSMP is used as a template for this purpose.
3. The output of this step is an initial draft of the FSMP document. *Initial FSMP documents are rarely "complete," in the sense of describing all of the implementation details of upgraded fire management capacity in the geographic area to which they relate.* The initial FSMP document instead describes how *existing* fire suppression resources could most efficiently be mobilized. The actual procedures for organizing and mobilizing fire suppression resources in the geographic area in question are sorted out as part of the overall FSMP exercise. The sorting out of standard operating procedures (SOPs) for mobilizing existing resources in the most efficient manner possible takes place during the FSMP exercise. As these SOPs are sorted out, the initial FSMP document is amended to reflect the SOPs and other measures for improving efficiency of fire suppression activities in the geographic area to which the FSMP relates.
4. The initial FSMP could therefore correctly be thought of as a vehicle for arriving at a destination (i.e., efficient fire suppression operations using existing resources), rather than as a destination in and of itself. In short, FSMPs are meant to evolve as the exercise proceeds, rather than sketching out in advance a description of the evolved fire suppression capacity that is the goal of the FSMP exercise. Thus, while a base time frame for formulation of an initial FSMP document would be somewhere of the order of 2-20 weeks, a best-case scenario time frame for completing the FSMP exercise would be a minimum of 18-24 months.
5. The second step in the FSMP exercise is to put into place an iron-clad, detailed inventorying and tracking system for all equipment and personnel that will be mobilized when the

mobilization plan is activated. This system *must* be sustainable without outside support. The recording system to be used in the Borneo and Sumatra cases should assume a complete lack of computer facilities. Manual recording should thus be assumed to be the basis of the inventorying and tracking system.

6. While at first glance such a system might seem technologically unsophisticated, this is the system used successfully for inventorying and tracking equipment and personnel in several countries with advanced wildland fire suppression capability. Until recently, computer-based systems were used as an adjunct to such manual recording systems. Manual-recording-based inventorying and tracking systems can function efficiently, and are often the best means of mobilizing resources from neighboring jurisdictions.
7. Computerized or not, *all* inventorying and tracking systems must—at the minimum—include the following information for each piece of fire suppression equipment: description, model number and specification; current status (available, unavailable, or committed); exact location; and most important, the contact information for the person authorized to release the piece of equipment in question. A similarly-detailed inventorying and tracking system must be put into place to catalogue contact information for personnel.
8. Once the inventorying and tracking systems for equipment and personnel have been put into place, the third step is undertaken, which is to conclude simple, written interagency agreements among all parties that have agreed to participate in the plan. This is perhaps the critical step in the FSMP exercise, since the details of how each agency cooperates in fire suppression activities must be agreed upon and specified *in writing* well in advance before addressing any fire emergency the FSMP is to address.
9. The fourth and fifth steps comprise the formulation and execution of a desktop mock drill, or Tactical Exercise without Troops (TEWT [pronounced "toot"], to use the correct fire suppression terminology). Formulating a TEWT is a more extensive process than executing a TEWT, and therefore is likely to require external expertise (either from a Subregional Firefighting Arrangement [SRFA] member country or an international fire management agency). The purpose of the TEWT is to test the adequacy of the FSMP, and to determine how it should be revised so as to strengthen it. TEWTs are preferred to real-world mock drills in the Association of Southeast Asian Nations (ASEAN) setting, since they can adequately point out weaknesses in existing FSMPs.
10. Following execution of the TEWT, the sixth step is undertaken, which is revision of the FSMP, so as to address any weaknesses uncovered by the TEWT. The seventh step is then ratification of the TEWT. The eighth step comprises formulating and implementing an annual review of the FSMP.
11. The 9th, 10th, 11th, and 12th steps pertain to formulating a program for upgrading of fire suppression capability under the auspices of the FSMP to an objectively-defined, predetermined level. The ninth step involves determining the personnel and training requirements for executing the upgrading program, while the 10th and 11th steps comprise determining the equipment and communications requirements for executing the upgrading program.
12. The 12th step is formulation of the upgrading program, which requires time, since all details of procurement, payment, inventorying, training must be transparently stated in the program.

13. The 13th step is the execution of the upgrading program, which includes the assimilation of all new equipment and training into the inventorying and tracking systems for equipment and personnel.
14. The 14th and final step is incorporating provisions for sustaining the FSMP over time.

(A summary outline of generic FSMP is given as Attachment 1)

Attachment 1

Summary Outline of Generic FSMP

Section 10 Objectives, Overall Procedures, and Participating Agencies
- 11 Objectives
- 12 Overall Procedures
- 13 Participating Agencies

Section 20 Administrative Procedures
- 21 Terminology
- 22 Scope of Operations
- 23 Levels of Coordination
  - 23.1 Communications Procedures
  - 23.2 Reporting Procedures
  - 23.3 Procedures Governing the Use of Satellite Imagery
- 24 Dispatch Procedures
  - 24.1 Mobilization
  - 24.2 Safety
  - 24.3 Accident and Incident Reporting
  - 24.4 Requests for Assistance
  - 24.5 Financial Procedures
  - 24.6 Demobilization Procedures
- 25 Incident Priorities
- 26 Aircraft Operations
  - 26.1 Procedures Governing Aircraft Operations
  - 26.2 Communications
  - 26.3 Funding Arrangements

Section 30 Organization

Section 40 Cooperation
- 41 Cooperative Arrangements

Section 50 Directory

Section 60 Personnel

Section 70 Equipment
- 71 Fire Suppression Equipment
- 72 Radio Equipment
- 73 Specialized Equipment

Section 80 Aircraft Inventory (if any)

APPENDIX 4

Fire Danger Rating Systems

Introduction

There are several fire danger rating systems (FDRS) available globally. They are, however, not being proposed for the Association of Southeast Asian Nations (ASEAN) region and will not be considered here. It is sufficient to say that most of these systems are fairly complex systems designed for the fuel types, soil behavior, and atmospheric conditions characteristic of their regions. Furthermore, some systems would require specific inputs that may not be readily available in the region or may entail additional measurement techniques.

The purpose of a FDRS is to alert the relevant authorities to a buildup of a seasonal fire risk so that appropriate preventive measures can be taken to reduce fires. In the tropics, the single most important factor that can lead to a buildup of fire risk is a deficit of rainfall. Vegetation that is moist is not susceptible to fire or does not burn easily. However, in the absence of rainfall, vegetation will start to dry out and fire risk increases. The extent of the drying out of the vegetation should be conveyed by a suitable fire risk index. Factors that can also affect the drying out process are temperature, wind, and humidity. In the tropics, these three factors do not vary significantly and may not add new information to a fire risk index.

An appropriate FDRS for this region needs to be:

1. simple and intuitive,
2. easy to implement,
3. economical to maintain,
4. requiring minimal input data,
5. yielding easy classification of fire risks, and
6. flexible for further development and expansion.

Canadian Fire Danger Rating System

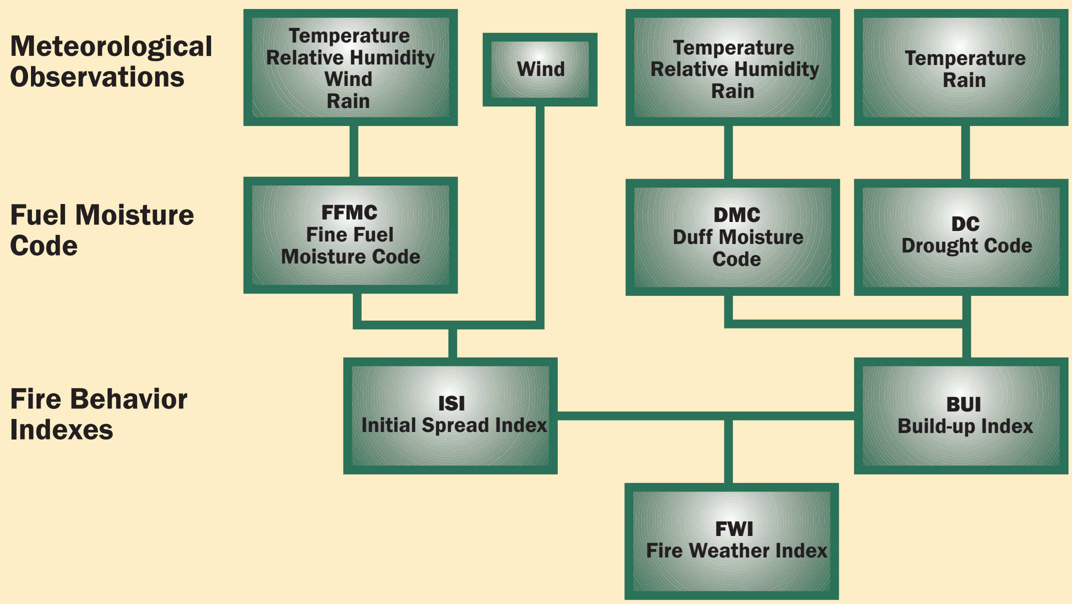
The Canadian system is a comprehensive FDRS consisting of five components. It is also the most complex system that is proposed and comprises five subsystems:

1. Fire Weather Index system,
2. Fuel Classification and Maps,
3. Fire Behavior Prediction system,
4. Wildfire Threat Assessment, and
5. Fire History.

Although there are five subsystems, the first component is considered the most important module of the whole system and can adequately perform as a stand-alone system. The inputs to this component are temperature, relative humidity, wind, and rainfall. (Refer to the flow chart overleaf for calculation of the fire weather index.)

The flow chart suggests that three important fuel types contribute to the computation of the final index. However, these fuel types are probably not applicable to the region and the appropriate fuel components need to be identified for the index to work properly. It could be a lengthy

FIGURE 5 **Flow Chart of Canadian Forest Fire Weather Index System**



Source: RETA 5778: *Strengthening the Capacity of the ASEAN to Prevent and Mitigate Transboundary Atmospheric Pollution* Draft Final Report.

exercise to determine moisture characteristics of tropical forests, plantations, peatswamps, etc., for the region. If it is recognized that the majority of forest fires are due to human activities, such a study while useful in the long term, may not address the immediate needs of the region.

The implementation of the index requires investment in new computing resources and extensive adaptation studies of the index to the region. Furthermore, the maintenance of the system within the Indonesian or ASEAN context may not be feasible.

Keetch-Byram

The Keetch-Byram Drought Index (KBDI) was originally developed to describe the dryness of fuels in the southeastern United States. It is basically a cumulative or bookkeeping index. To use the index requires heavy rainfall exceeding 200 millimeters when the index is set to zero. Subsequently, on a daily basis, an amount is *subtracted* (to represent drying by evaporation during the last 24 hours from a look-up table) on a no-rain day or the rainfall equivalent is *added* if there has been rain during the last 24 hours. The other meteorological inputs are maximum temperature and relative humidity.

The advantage of the KBDI is its simplicity of usage and familiarity among fire managers. The KBDI has been used by the Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) for East Kalimantan for some years already. The ASEAN Specialized Meteorological Centre (ASMC) is testing a trial system of the KBDI for Sumatra and Kalimantan.

The disadvantage is that there has not been any rigorous validation or calibration of the KBDI either in the tropics or elsewhere outside the region of the southeastern United States. It assumes a maximum of 2,000 for the index and drying factors of the fuel, forest type, and soil structure similar to those of the southeastern United States. This is not strictly correct since the drying force of a dry and arid environment would be different from the moist and hot environment of the tropics. Without a proper recalibration of the drying tables, the KBDI will seriously overestimate the fire risk in the tropics. However, some compensation has been incorporated in the KBDI by having different drying tables based upon average rainfall, assuming that more humid environments have a higher rainfall.

Despite its weaknesses, it is a simple and intuitive index. The input meteorological parameters are readily available to ASEAN National Meteorological Services and can be easily computed with existing resources. ASMC can extend the KBDI to other parts of ASEAN when the trials have been completed.

Rainfall Debt

The Report of the ADTA INO 2999 recommends the use of a rainfall debt as an early warning indicator of fire risk. In the tropics, where maximum temperature and relative humidity do not vary significantly from day to day, the information content of an index is not substantially increased by incorporating these two parameters. Similar arguments apply to wind and other classic parameters of a fire danger model.

The most important parameter is the last 24-hour rainfall. Solar radiation as expressed through cloudiness may affect evaporation rates to some extent and should be evaluated for its contribution to the rainfall debt.

The calculation of this simpler index consists of subtracting the 30-day running rainfall total against the normal monthly mean rainfall. This rainfall deficit can then be expressed as a percentage of the normal monthly mean rainfall. Thereafter, this value is to be known as rainfall debt.

Rainfall debt is an intuitive concept and relates to the relative dryness of a region with respect to its monthly mean rainfall. At selected rainfall debt levels, fire risk warning levels can be triggered and relevant authorities can take the appropriate action. Such a value can be easily calculated as long as one has daily rainfall measurements in the region.

The rainfall debt concept is still in its developmental stage for the region and has to be evaluated for its appeal and effectiveness as a fire risk indicator. The rainfall debt values can be evaluated for a period of several months prior to the haze in 1997 until several months after the haze in 1998. The exercise could determine the rainfall debt levels appropriate to trigger heightened fire risk level warnings to be set in place.

Recommendations

The recommendations of the ADTA and RETA 5778 are for the KBDI and Rainfall Debt to be implemented concurrently. The KBDI is readily acceptable to fire managers and is already being operationally implemented in East Kalimantan by GTZ. ASMC is evaluating the KBDI against the haze of 1997 and 1998 for the regions of Kalimantan and Sumatra.

Simultaneously, a trial is being carried out to operationally calculate the KBDI for Kalimantan and Sumatra using daily meteorological data. ASMC has carefully selected a list of stations on Kalimantan and Sumatra that have available daily rainfall and maximum temperature data to compute the KBDI. The number of stations will be expanded when more data become available.

Rainfall debt is a new suggestion but the concept is simple and practical. It is likely to gain acceptance in the region because it is easy to implement and economical to maintain. Further, fire risk associated with rainfall deficit is intuitive as well as common knowledge. ASMC can evaluate the rainfall debt for the haze of 1997 and 1998 in order to assess its suitability as a fire risk indicator. If the evaluation is positive, the rainfall debt can be first implemented by ASMC for Kalimantan and Sumatra. At a later stage, the rainfall debt computation can be expanded to other ASEAN member countries (AMCs).

Technical Expertise and Training Requirements

Both KBDI and Rainfall Debt can be easily implemented by national meteorological services. The meteorological data required is already available on a daily basis, and past climatological data can be used to evaluate the effectiveness of the indexes in each country. ASMC can provide basic training, if any is necessary, to help set up the capability in individual AMCs.

Source: RETA 5578: *Strengthening the Capacity of the ASEAN to Prevent and Mitigate Transboundary Atmospheric Pollution* Draft Final Report.

APPENDIX 5

Donor and Partnership Activities

There has been a general concurrence throughout the Operationalized Regional Haze Action Plan (ORHAP) process that the fire-and-transboundary-haze issue confronting the Association of Southeast Asian Nations (ASEAN) region is a problem that is so large that no single agency can address it. Funding agencies have been equally aware of this fact throughout the fires and haze that have impacted the region over the past two decades. In fact, donors have provided a substantial amount of funding to short-term suppression activities. While this has no doubt been appreciated by the ASEAN member countries (AMCs), sustained funding of short-term fire suppression over an indefinite period is neither feasible, nor would it be an efficient use of scarce funding or affected-country resources.

The challenge now is to use the intervening period between the end of the recent *El Niño* and the onset of the next to put into place an institutional framework that will prepare the ASEAN region for subsequent periods of vulnerability to fires and transboundary haze. This preparation should enhance ASEAN's capability to manage periods of heightened risk of large-scale fires without resorting to a crisis management mode of response, as it did during the 1997-1998 fire-and-haze disaster.

Accomplishing this will require funds to be used as efficiently as possible. This means that the role of the funding agencies in addressing the fire-and-haze issue will also have to evolve. In short, fire-and-haze-related activities must now be integrated via explicit partnerships, rather than simply becoming aware of "what other funding agencies are doing about the fires and haze."

A start has been made in this direction by integrating funding agencies' activities directly into the RHAP Detailed Implementation Plan (DIP). When used as it was intended, the DIP places the onus of developing an integrated operational plan for confronting the fire-and-haze issue directly on to the AMCs and ASEAN itself. Once the ASEAN region has determined the actions it needs to take to address fires and transboundary haze, the financial costs of these actions can be determined, and the areas where gaps between available AMC resources and requirements exist can be identified. At this point, it is appropriate for funding agencies to determine which of these gaps they can most efficiently fill, given their particular emphasis or area of expertise. The scenario described directly above is the manner in which the funding agencies can most effectively make use of the RHAP DIP.

Because of the urgency of the fire-and-transboundary-haze issue, RETA 5778 temporarily performed the dual role of operationalizing the concept of DIP as a planning tool, and simultaneously catalyzing integration of fire-and-haze-related funding agency activities directly into the emerging ORHAP DIP. Once the plan is fully operationalized, it is more important to manage the information necessary for funding agencies to be able to use the ORHAP DIP as their own planning tool.

Several funding agencies have become directly involved and integrated into the ORHAP DIP process. The activities of these donors are briefly described (in alphabetical order by donor name) below, in order to make funding agencies new to the ORHAP DIP process more conversant with the roles that those already involved are playing, and how these roles fit into the overall ORHAP DIP.

* * *

Australia announced a contribution of A$660,000 to the ASEAN fire-and-transboundary-haze initiative in late July 1998. These funds were to be used to support three separate components. First, a contribution of $100,000 equivalent will be used to directly support the ADB RETA Project's program of activities, and will include funding for three applied studies: (a) Operationalization and Refinement of AMC National Haze Action Plans, with particular reference to Indonesia; (b) Formulation of a Fire Mitigation Training Program for the ASEAN Region; and (c) Formulation of an operating procedure for activating fire suppression resources in AMCs, with particular reference to Indonesia (other outputs, including formulation of possible long-term solutions to the fire-and-haze issue, and a broad-brush plan for upgrading Indonesia's communication infrastructure for fire suppression, will also be generated by this study).

The second component of Australia's contribution will support component 1 of the Programme to Address Regional Transboundary Smoke (PARTS), which was formulated by the World Meteorological Organization (WMO). PARTS component 1 will increase ASEAN's capability in using satellite monitoring to prevent, detect, and track fires and haze in the region. Support for this component will be channeled through the United Nations Economic and Social Commission for Asia and the Pacific (UN-ESCAP). The third component of the Australian contribution (now being programmed) will support fire mitigation activities, or more likely, training of firefighters.

* * *

BIOTROP-GCTE Impacts Center for Southeast Asia (IC-SEA) is now actively studying the many facets of the link between national level economic and natural resource policy with the use of fire as a tool for land-clearing or a weapon. Three studies of this type are ongoing and a fourth study on the health impacts of haze will integrate the work that Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) and the World Health Organization (WHO) have done in this area.

* * *

The **Canadian International Development Agency** (CIDA) is preparing a system for implementation of its Fire Danger Rating System (FDRS) in the region. This system, which includes fire risk mapping, will initially be implemented in three AMCs: Indonesia, Malaysia, and Singapore. In order to ensure AMCs' ownership of the system, counterpart funding will account for about half of total direct implementation costs.

* * *

The **European Union** (EU) is linking activities under its ongoing Forest Fire Prevention and Control Project with activities of the SRFA-Sumatra. This project operates at community level and includes training, satellite monitoring, early warning and fire danger rating, and other activities. The early warning and/or fire danger rating system is being integrated with CIDA's FDRS described.

* * *

GTZ has an ongoing Integrated Forest Fire Management Project (IFFM) in East Kalimantan that includes numerous components, one of which is fire danger rating. Like the EU early warning system, the GTZ system is being integrated with CIDA's FDRS. GTZ is also actively involved with the Consultative Group on Indonesian Forestry in numerous forestry policy areas, and has ongoing work on the health impacts of haze in Indonesia.

* * *

Hanns Seidel Foundation (Germany) is directly supporting the activities of RETA 5778 by providing the costs of air transport and sponsorship for three German interns (two to six person-months each) that will work together with the Project Management Unit (PMU) specialists in the areas of forest fire management, information management, and policy and legislation analysis.

The newly-established Southeast Asia Fire Monitoring Center (University of Freiburg, Germany) is planning to link up with ASMC and activities of the ORHAP.

* * *

Japan International Cooperation Agency has a satellite monitoring initiative based in Kalimantan, and a community-based Forest Fire Prevention and Management Project (FFPMP) in Indonesia.

* * *

The **United Nations Environment Programme** is supporting a number of activities relating to operationalization of the RHAP via its Emergency Response to Southeast Asian Fires Project. Major components supported by this $750,000 project include: (a) funding agencies' coordination, (b) an international meeting for organizing short-term fire suppression activities, (c) aerial surveillance operations under the SRFAs, (d) training for firefighters, (e) public awareness, and (f) early warning and/or fire danger rating. Component f will complement and be integrated with the CIDA FDRS.

* * *

United States is supporting operationalization of the RHAP via its Southeast Asian Environment Initiative (SEA-EI). The SEA-EI includes two components: (a) a regional component that will support 10 subprojects, for a total amount of $4 million, and (b) an Indonesia-only component, for a total amount $2 million.

The SEA-EI's regional component, each of which will be implemented by a US Government agency, includes the following subprojects: (1) upgrading of ASMC's capacity in climatological forecasting (US National Oceanic and Aeronautics Administration [NOAA]); (2) upgrading of ASMC's capacity in haze transport modeling (Environmental Protection Agency [EPA]); (3) upgrading of ASMC's capacity in haze monitoring (EPA); (4) analysis of the health impacts of haze (EPA); (5) guidelines on the health impacts of haze (Center for Disease Control and Prevention [CDCP]); (6) technical assistance on peat fire suppression (US Forest Service); (7) technical assistance on coal seam fire suppression (Office of Mines, US Department of the Interior); (8) reduced impact timber harvesting (to make logged forests less vulnerable to fire) (US Forest Service); (9) support to the Asian Disaster Preparedness Centre, Bangkok (US Office of Foreign Disaster Assistance); and (10) analysis of the impact of the 1997-1998 Fires and Haze (partial funding to a project undertaking this work that will be performed by the Centre for International Forestry Research in conjunction with the International Center for Research in Agroforestry, both located in Bogor, Indonesia). The regional component also supported provision of a forest fire management expert from the US Forest Service directly to the PMU, who worked together with the regional technical assistance forest fire management specialist.

WHO prepared Guidelines on the Health Impacts of Haze, which will be valid worldwide for all haze generated by large-scale land and forest fires.

* * *

WMO has formulated PARTS (described above), and is actively involved in numerous activities that support upgrading of the ASEAN Specialized Meteorological Centre (ASMC). These activities include a series of workshops on transboundary atmospheric pollution, the first of which was held in Singapore on 2-5 June 1998.

* * *

The World Bank has rechanneled $300,000 in unused funds from an earlier project with the BAPEDAL, Indonesia. These funds will now be used for three initiatives relating to fires and haze, one of which is formulation of a proposal for an ASEAN-wide Firefighting Training and Research Center at the University of Palangkaraya, Indonesia.

* * *

The wide-ranging support described above is clear evidence of funding agencies' commitment to address the problems related to the forest fires and associated transboundary haze. It augurs well for the ORHAP. Nevertheless, numerous gaps still remain, as is apparent from even a casual analysis of the DIP. This would point to the need for enhanced and targeted funding agency support and collaboration. As all participating funding agencies will ultimately have access to the intranet version of the ORHAP, the opportunities available and the roles each can play will become increasingly apparent (see Attachment 1).

Attachment 1

Updated Position of Funded Projects in Direct Support of ORHAP Implementation (catalyzed by the Asian Development Bank Regional Technical Assistance Project)

AusAID

1. Three-component program of support to ASEAN in addressing fires and transboundary haze (A$660,000);
   - $100,000 (A$160,00) direct to RETA-PMU to support:
     - Study on Formulation of Operating Procedure for Activating Forest Firefighting Resources in the ASEAN Region with Particular Reference to Indonesia. (Mitigation)
     - Study on Training in Fire Management in the ASEAN Region. (Mitigation)
     - Applied Study on Formulation of National Haze Action Plans with Particular Reference to Indonesia. (Mitigation)
   - A$200,000 direct support to training in fire management (with option to switch these funds to the component directly below. (Mitigation)
   - A$300,000 direct support (via UN-ESCAP) for implementation of PARTS component 1. (Monitoring)

2. Direct support (provision of one forest fire management specialist) to the Inventory and Assessment of Fire Management Capacity in the ASEAN region. (Mitigation)

CIDA

1. Funding of a feasibility study on a Fire Danger Rating System for the ASEAN Region. (Prevention)
2. Direct support (provision of one forest fire management specialist) to the inventory and assessment of fire management capacity in the ASEAN region. (Mitigation)
3. Funding of implementation of the Haze Technical Task Force (HTTF)-endorsed Fire Danger Rating System for the ASEAN Region. (Prevention)

EU

1. Direct support in the form of backstopping to the Inventory and Assessment of Fire Management Capacity in the ASEAN Region. (Mitigation)
2. Direct support in the form of backstopping to the formulation of Prototype Fire Suppression Mobilization Plans for critical districts in Riau and South Sumatra Provinces. (Mitigation)

GTZ

Implementation of a study on the health impacts of haze in Indonesia. (Prevention)

Hanns Seidel Foundation

Catalyzing of interns from the University of Passau that provided direct general support to RETA PMU, and direct support in the form of backstopping to the Inventory and Assessment of Fire Management Capacity in the ASEAN Region. (Mitigation)

WHO

Convening of a Workshop on the Health Impacts of Transboundary Haze Pollution in the ASEAN region. (Prevention)

WMO

Convening and cofinancing (with RETA 5778) of a workshop on Transboundary Atmospheric Pollution in the ASEAN Region. (Monitoring)

UNEP

Provision of experts in international legal instruments relating to negative environmental effects. These experts wrote the concept paper for a Framework Agreement on Transboundary Pollution in the ASEAN Region, as well as terms of reference for a feasibility study on Formulation of a Framework Agreement on Transboundary Pollution in the ASEAN Region. (Prevention)

USAID

Implementation of the Southeast Asia Environment Initiative, which included 10 subprojects as follows:

Related to Prevention Program of ORHAP

- Strengthening Capacity in Disaster Readiness in the ASEAN Region (with the Asian Disaster Preparedness Center).
- Analysis of the Human Health Impacts of Transboundary Haze in the ASEAN Region during the 1997-1998 fires and haze (US EPA).
- Identification of a further research agenda on the Human Health Impacts of Transboundary Haze in the ASEAN Region (US CDCP).

Mitigation Program of ORHAP

- Technical Assistance to Development of Techniques for Coal Seam Fire Suppression in the ASEAN Region.
- Technical Assistance to Development of Techniques for Peat Fire Suppression in the ASEAN Region.
- Strengthening Fire Management Capacity in the ASEAN Region (three components).
  - Direct support to RETA-PMU in the form of assistance to the RETA Forest Fire Management Specialist.
  - Funding and provision of six senior fire management experts for the Inventory and Assessment of Fire Management Capacity in the ASEAN Region.
  - Funding and provision of six senior fire management experts for the formulation of Prototype Fire Suppression Mobilization Plans for critical districts in Riau and South Sumatra Provinces.

Monitoring Program of ORHAP

- Provision of financing and technical expertise for implementing PARTS component 2 (US NOAA with ASMC).
- Provision of financing and technical expertise for implementing PARTS component 3 (US NOAA with ASMC).
- Study on the formation, transport, and dispersion of transboundary haze pollution in the ASEAN region (US NOAA with ASMC).
- Study on strengthening the monitoring of transboundary haze pollution in the ASEAN region (US NOAA with ASMC).

APPENDIX 6

Outline of the Haze Action Online and Some Aspects of the Design Standards

Part I. Outline of the Haze Action Online

Introduction

The Operationalized Regional Haze Action Plan (ORHAP) is a complex undertaking. Apart from the regional level plan, it involves implementing the nine (soon to become 10) National Haze Action Plans (NHAPs) and two (and possibly more) Subregional Firefighting Arrangements (SRFAs). Separate Detailed Implementation Plans (DIPs) (12 soon to become 13) have been correspondingly formulated to supplement each action plan and to help determine the minimum implementation strategy of actions, activities, and funding and investment requirements necessary to implement the ORHAP. While the various Action Plans and their corresponding DIPs provide a medium-term accounting and projection of efforts required to mobilize the ORHAP, a six-year implementation program has also been established to strengthen regional fire suppression capacity, principally through Fire Suppression Mobilization Plans (FSMPs) and SRFAs.

Three high-level Association of Southeast Asian Nations (ASEAN) bodies (ASEAN Ministerial Meeting on Environment [AMME], ASEAN Ministerial Meeting on Haze [AMMH], and ASEAN Senior Officials on Environment [ASOEN]) are accountable for ORHAP implementation, while specialized ASEAN agencies and subgroupings (the ASEAN Secretariat, the Haze Technical Task Force [HTTF], the three HTTF lead countries, the HTTF Working Groups of SRFA-Borneo and SRFA-Sumatra, and ASEAN Specialized Meteorological Centre [ASMC]) are responsible for technical implementation of the ORHAP. Also included are the national meteorological services (NMS), the national fire suppression agencies, the national disaster coordination authorities, funding agency collaborative partnerships, nongovernment organizations (NGOs), and private sector organizations. Within the ASEAN Secretariat alone there are six different units that collect and disseminate fire-and-haze-related information.

The key informational materials of this operational structure and framework comprise the following constituent elements:

- RHAP umbrella document;
- ORHAP document elucidating the general strategy and guidelines for RHAP implementation along with a six-year operational program;
- DIP of the ORHAP;
- DIPs for the SRFAs (Borneo and Sumatra);
- DIPs for the NHAPs (for all ASEAN member countries);
- Fire Suppression Mobilization Plans (FSMPs);
- Inventorying and Tracking System for Fire Suppression Resources;
- ASMC-Centered Monitoring and Hydrological-Meteorological Information System;

- collaborative partnership programs and projects; and
- framework of international agreements and protocols.

The documents and informational materials can be categorized into formalized (dynamic and static), nonformalized referenced, and nonformalized, plus other information and data sets. The complexity of the ORHAP operational framework necessitates a carefully planned and designed information technology solution. For this purpose, the establishment of an Information Management System (IMS) is highly necessary and feasible. The IMS will be at the core of the Regional Information Center and Clearinghouse. Details of the requirement analysis, logical and physical design, conversion requirements, and implementation are provided.

Requirement Analysis

External connectivity through the Internet allows for the exchange of data interactively. The Internet is recognized as a reliable medium to share data of all types. It is also possible to utilize the Internet for secure data transmission cost-effectively by utilizing the "intranet" aspect (ADB/ ASEAN 1999).

Feasibility of Intranet Utilization

The term intranet defines a computer network, or the sum of several networks in a certain geographical area, which runs on the Internet protocol. This approach enables the use of the same type of data servers and data browsers used for the World Wide Web for internal applications distributed over a Local Area Network (LAN), or Wide Area Network (WAN). Because intranets are based on the Internet protocol, they are platform-independent. Hence Windows, Macintosh, Novell, and UNIX networks can all share information by overlying TCP/IP on their existing network transmission protocol. In economic terms and because of this feature, intranets are generally inexpensive to implement. The majority of HTTF member countries, their focal points, key supporting agencies, and the ASEAN Secretariat have Internet connectivity, making the use of the Internet as a way of networking, broadcasting and transmission, and database management highly feasible. All information, data sets, and databases of the IMS could be adopted to suit Internet technologies.

Logical Design

The IMS study of RETA 5778 recommends the bifurcation of the IMS into a publicly accessible Internet system and a virtual private network utilizing the Intranet. Internet technologies make it possible for such a system to reside in one web site. The focus here is on the requirements for an intranet system, which will be the most vital component in direct ORHAP IMS implementation.

To implement an intranet within any organization it is important to distinguish between two distinct components: content and transport. The term "content" describes the actual data distributed through the intranet, while the "transport" is the mechanism that carries the data from its origin to its destination(s). Virtually all the information systems identified can be computer-automated, but certain systems comprise of, or are supplemented by, a manually driven system.

Physical Design

There are several design options in linking the ASEAN bodies responsible for ORHAP implementation. These are summarized in the following table:

TABLE 6 **Design Options**

Type	Advantages	Disadvantages
Dedicated connection (leased line circuit between Secretariat and other countries)	High level of security; high speed	Very high cost
Internet connection	Good security with secure-server software; low cost	Lower speed than dedicated connections (depends on country access speed, in most case acceptable)
Internet connection with tunneling protocol	Security almost at same level of dedicated connection; low cost.	Lower speed than dedicated connection (depends on country access speed, usually acceptable)

The table shows the most common solutions. Initially, the system can be operated by restricting external users access through user name and/or password requirements. Once the intranet is in place, external users can access the information and update database forms through a log on process. This is usually secure enough for piloting purposes. After the system is stabilized, the LAN manager can install a tunneling protocol for additional security. A tunneling protocol is a set of data transmission rules that establish a virtual "pipe." Data can then be securely moved inside the pipe between two points. Although the pipe itself is not considered secure, the data it contains are accessible only from the originating and destination points. Tunneling protocol is used today to establish inexpensive Private, Virtual Networks (PVNs) using regular Internet Service Provider (ISP) networks.

A specialized ASEAN Internet and intranet web site without a tunneling protocol, based on a Windows NT operating system (and the related Microsoft Internet information services and other Internet network services that the Windows NT offers) named "ASEAN Haze Action Online" has already been established.

Implementation

ADB's RETA Project had installed for its Project Management Unit (PMU) and Coordination and Support Unit (CSU) a Sub-LAN Windows NT operating system for networking the project among staff and consultants within the ASEAN Secretariat. This system has been upgraded with the appropriate Internet technology into a full-service web server for the enhanced IMS of ORHAP with the site address: **www.haze-online-or.id**

CSU will be responsible for the content of the web site, that is, the overall "look and feel" of the intranet site, and for keeping the information fresh and well organized, This requires updating the material to the site on a daily basis, or sometimes continuously through the day. It is also necessary to establish "entry points" throughout the ORHAP institutional arrangement to input data directly into the Intranet. CSU should also be responsible for maintaining a logical, coherent, and easily navigable menu structure. Other CSU responsibilities include the creation of hypertext markup language (HTML) pages, the creation of the forms used in formulating and returning database queries, and sometimes even the programming of the query mechanism itself. Competence and training in the following areas are required:

- HTML language;
- use of graphic applications and image manipulation;
- scanning techniques;
- database technology; and
- office procedures and archival schemes.

Part II. Design Standards

Based on the regional fire and haze information and web design techniques available to date, the following design standards have been compiled for designing the ASEAN Haze Action Online web site. When designing or redesigning a web site, each of these guidelines should be applied where appropriate.

Background and Objectives

Operationalizing the RHAP ultimately depends on an efficient flow of information among the various parties, agencies, and countries implementing the Plan at the national, subregional, and regional levels. The information management system is the means by which implementation of each action defined in the DIP at each of the levels is monitored.

The heart of the ORHAP information management system is a computerized retrieval system that can be accessed through the Internet. The Intranet Information System also provides up-to-date information to help in decision making.

ASEAN Haze Action Online allows the sharing of knowledge and experience, and coordination and monitoring of national, regional, and international initiatives with institutions in the region. This includes an intranet linking institutions in the region and a public information service.

The establishment of the ASEAN Haze Action Online Internet/intranet information system is based on one of the RETA 5778 terms of reference components to develop, establish, and operationalize an improved information management, exchange, and dissemination system in the ASEAN Secretariat related to fires and haze prevention and mitigation.

The objectives of the establishment of the ASEAN Haze Action Online Internet/Intranet Information System are to:

1. provide a medium for information exchange between institutions at the regional and national levels;
2. support and monitor implementation of regional, subregional, and national haze action plans;
3. provide a link to ASMC's products;

4. support and monitor implementation of the ASEAN Regional Fire Suppression Mobilization Plan;
5. provide a database and/or inventory of equipment, firefighters, fire experts, and addresses of contact persons and institutions at regional and national levels;
6. provide information on meetings and events, a calendar, and scheduling;
7. provide a library of information and/or document center related to fires and haze;
8. provide linkages to all of the available fire and haze information sources on the Internet;
9. provide comprehensive, accurate, and up-to-date information on all funding agency projects that are supporting the regional, subregional, and national haze action plans;
10. provide funding agencies with a full range of project coordination functions to better target development assistance by matching specific needs to funding agency priorities;
11. provide the ASEAN Secretariat with an alternative medium for public awareness, education, and outreach programs on fire-and-haze-related information; and
12. provide the ASEAN Secretariat with a medium for internal awareness and outreach program on fire-and-haze-related information.

Target Users

In order to create compelling and useful content and applications, target users should be defined. Once the site is implemented, user feedback and analysis of user log files generated by the web tracking system should be used both to fine-tune the site and to confirm the users.

The ASEAN Haze Action Online web site will target the following:

- AMME;
- AMMH;
- HTTF;
- government agencies responsible for the fire and haze prevention, monitoring, and mitigation activities;
- ASEAN Secretariat:
  - Environment Unit,
  - Information and Library Unit,
  - Culture and Information Unit,
  - Agriculture and Forestry Unit,
  - Computer Unit, and
  - Coordination Support Unit;
- collaborative partners; and
- the general public.

Any addition to the web site should be tailored to these users.

Site Structure

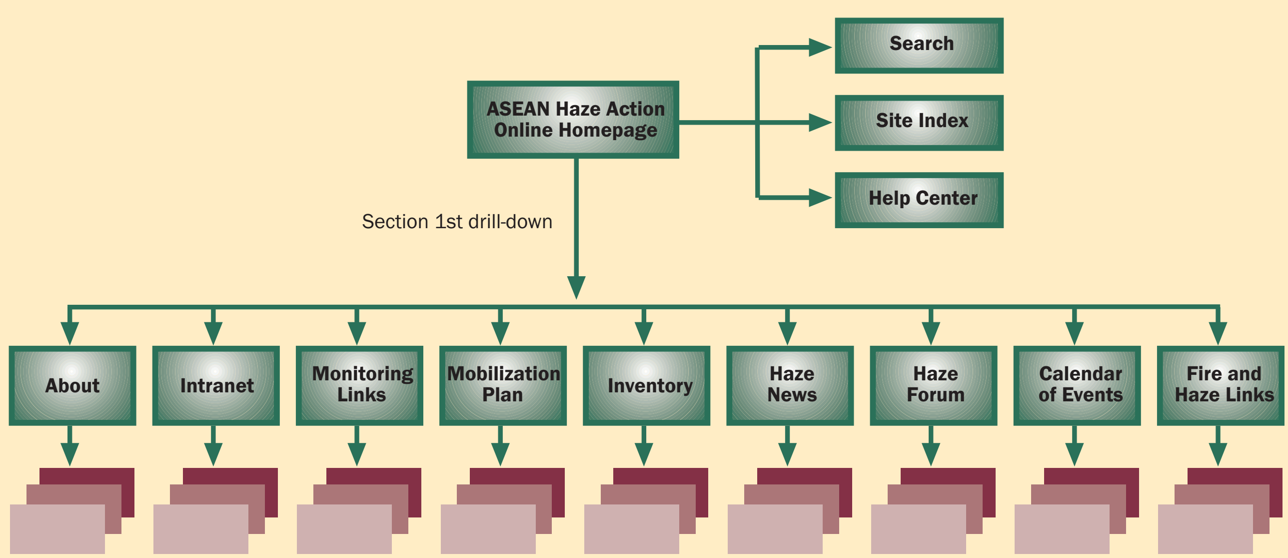
Users need predictability and structure with clear functional and graphic continuity between a site's sections and subsections. Below is the structure of the ASEAN Haze Action Online web site and a short description of the major sections. Any new content to be added to the web site should fit into this structure.

- ASEAN Haze Action Online Homepage: www.haze-online.or.id
- Search: Search ASEAN Haze Action Online web site.
- Site Index: Table of Contents to quickly locate information within the site.
- Help Center: Help on how to access and/or navigate through the site.

Section 1 drill-downs

- About: A brief introduction to ASEAN transboundary haze initiatives and the RHAP
- Intranet: Registered users (HTTF members, partners) can access the following RHAP information management tools:
  - DIP information system,
  - information on donors' collaborative partnership program and projects,
  - RHAP Document Center,
  - contact information databases for all persons and institutions concerned with RHAP implementation,
  - Calendar of Events and Activities database, and
  - Firefighting Resources Inventory System and Intranet Discussion Forum.
- Monitoring Links: Hyperlinks to the web sites of institutions specializing in monitoring of fires and haze in the region.
- Mobilization Plan: Information on ASEAN regional FSMP initiatives.

FIGURE 6 **Site Structure**



Source: ASEAN, RHAP-C54.

- Inventory: Information on the regional inventory and assessment of fire management capability.
- Haze News: New reports, press releases, situation summaries, links to the online version of the *International Forest Fire News*, and other information about the current fire-and-haze situation in the region. Users can also use this feature to suggest additional fire-and-haze hyperlinks.
- Haze Forum: An electronic forum allowing users to post their views and opinions on fire-and-haze-related issues, and to discuss them with other users.
- Calendar of Events: This feature gives the schedule and venue of all past, present, and future fire-and-haze-related events including seminars, workshops, training classes, and other activities.
- Haze Links: Links to other fire-and-haze-related web sites. Users can also use this feature to add Uniform Resource Locator (URL) links to the fire-and-haze-related web sites.

Supported Browsers

The ASEAN Haze Action Online web site is designed for the latest release versions of the Netscape Navigator and Microsoft Internet Explorer browsers. The reasoning for this decision is as follows:

- Cost: The more browsers that are supported, the greater the cost to develop the web site.
- Popularity: Netscape and Microsoft clearly lead the Internet browser market.
- Supported features: Both Netscape and Microsoft's browsers support many advanced technology features (i.e., Java, Shockwave, etc.). These companies are pushing each other to add functionality, which is causing their products to converge.

The ASEAN Haze Action Online web site is not implementing features that are not common to the identified browsers. If a feature is supported by one of the identified browsers and not by the other (i.e., VBScript), it should not adversely affect the look and feel of the site when viewed in the unsupported browser. And as Internet Explorer and Navigator converge, this issue will become negligible.

[Note: For details on Standard Page Design, HTML Coding Standards, System Architecture, etc., see the Final Report of ADB's RETA 5778: *Strengthening the Capacity of the ASEAN to Prevent and Mitigate Transboundary Atmospheric Pollution.*]

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